POWER

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The Business End of the Power Plant

LOWER cost for power means increased dividends. However, as the power plant is not classed as a productive division, the possibilities for increased economy there are often overlooked; a productive department produces the marketable goods and therefore seems worthy of more attention. But do the figures of the last audit substantiate that belief? Certainly not. Although the power cost forms a small per cent. of the total costs in nearly all industries, it runs into thousands of dollars, and losses there reduce the dividends the same as losses in other departments. And, *a thousand dollars saved or spent in the power plant is real money.*

This foreword is written chiefly for the power-plant owner.

The engineer should pass along his copy to the owner, superintendent or manager, as there is much of interest in it to them.

It is the engineer's business to furnish maximum power at a minimum cost, but, to do this, he must be supported by the management. The productive and selling departments demand great attention, but if a part of what is gained there is lost in the plant, the whole organization needlessly suffers. Therefore help the engineer to improve the service and he will furnish it at a figure that only the plant itself may excel.

European manufacturers, particularly the Germans, whose industrial and commercial thoroughness enables them to drive out all competitors supplying South American markets, and nearly all in the Oriental markets, devote much attention to their engineers and power plants. They help support engineering schools and buy testing instruments and apparatus with which the engineer may detect, remedy and prevent thermal and mechanical losses. It's not charity; it's a very profitable investment which the manufacturer is anxious to make. A few of the advantages gained are: High-class service at low cost, freedom from labor troubles, astonishingly few accidents and a low maintenance cost.

The engineer desires that the firm have something more than continuous service. He knows that uninterrupted power may be supplied to the producing machinery and yet be poor because of its high cost. Therefore consider his advice and recommendations. Furnish him with record and report forms that he may record the performance of the plant. There is no better way of improving a plant than by analyzing its operation by reference to records. They reveal weaknesses that are difficult for the engineer to discover otherwise.

Competition is *fierce* in the market receiving the manufactured goods, but it does not end there. The company's power plant also has a competitor that sells power for *profit*. It is watching for those weak spots that the engineer could have prevented if the management had given him support, and when the time is ripe will advance with smooth speech and convincing-looking figures to show the fallacy of generating power instead of buying it. If fair and thorough investigation shows that it is cheaper to buy it, do so. But help the engineer, and call in a consulting engineer, if he recommends it, to aid him in generating power cheaper than it can be bought. The profits will then remain in the company's vault instead of being charged to the expense sheet.

McCalls Ferry Hydro-Electric Plant

By Charles H. Bromley

SYNOPSIS—The McCalls Ferry hydro-electric plant on the Susquehanna River, near Lancaster, Penn., is within a radius of 70 miles of where over 750,000 hp. is developed by steam. The present rated capacity is 84,500 hp. and another 17,500-hp. unit is being installed. Provision is made for three more 17,500-hp. units, making an ultimate rated capacity of 155,000 hp. The tailrace of this plant is a natural one. The current of the river is such as to carry away all ice. The entire daily load, averaging 30,000 kw. with a maximum peak of 61,000 kw., is now going to Baltimore. The generators deliver three-phase, 25-cycle current at 11,000 volts and it is transmitted at 70,000 volts.

Historical

The location of the McCalls Ferry plant is ideal. Within an economical transmission radius of 70 miles are several of the largest cities of Pennsylvania, Maryland and Delaware. The map, Fig. 1, shows cities within this radius.

The site for the plant had been under consideration for many years, the investigations being carried on by George S. Morrison, deceased. The river showed a record flood of 225 volumes of low-water discharge. A series of rapids above the present location make available a head of 63 ft. This site was determined by Mr. Morrison.

About 1905 the McCalls Ferry Power Co. was incorporated with a capital of $10,000,000. This company designed the present dam and power house and carried on the construction work until 1907, when the financial panic of that year caused the company to fail. It will be understood that this failure was purely a financial one. The engineering scheme was successfully laid out as is evidenced by the fact that the present owners, the Pennsylvania Water & Power Co., which took over the plant about two years after the first company failed, has practically carried out what was initially planned.

The engineering organization of the McCalls Ferry Power Co. consisted of Carey T. Hutchinson, 60 Wall St., New York City, as chief engineer. The hydraulic plant was designed and partially executed by Hugh L. Cooper, 60 Wall St., New York City. Beverly R. Value was engineer in charge of construction.

Construction

The plant and dam were built by day's labor, as exhaustive study of conditions proved this course the best. The dam is approximately 2370 ft. long, 53 ft. high, with a base width of 65 ft. To allow for expansion and

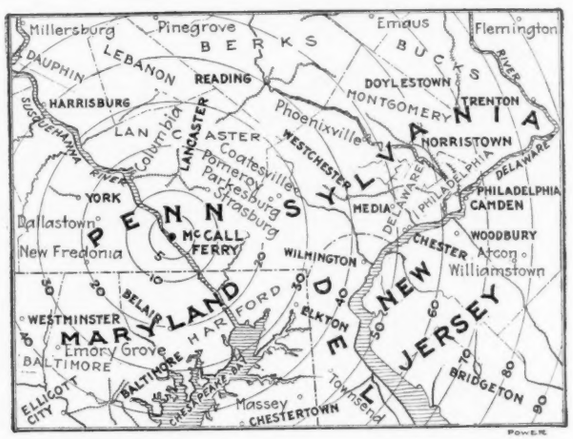


Fig. 1. Map Showing Cities within Economical Transmission Distance

contraction, and thus avoid cracking and deformation, layers of compressible material were inserted at intervals of 40 ft.

The Susquehanna is a widely and suddenly fluctuating river, and special provisions were necessary in constructing the dam. The dam was thus built in alternate sections, each 40 ft. long, average height 53 ft. with a 40-ft. space between each section to provide for a flow of 50,000 cu.ft. per sec. These spaces were filled in later to form a solid dam. To stop the openings between sections, hol-

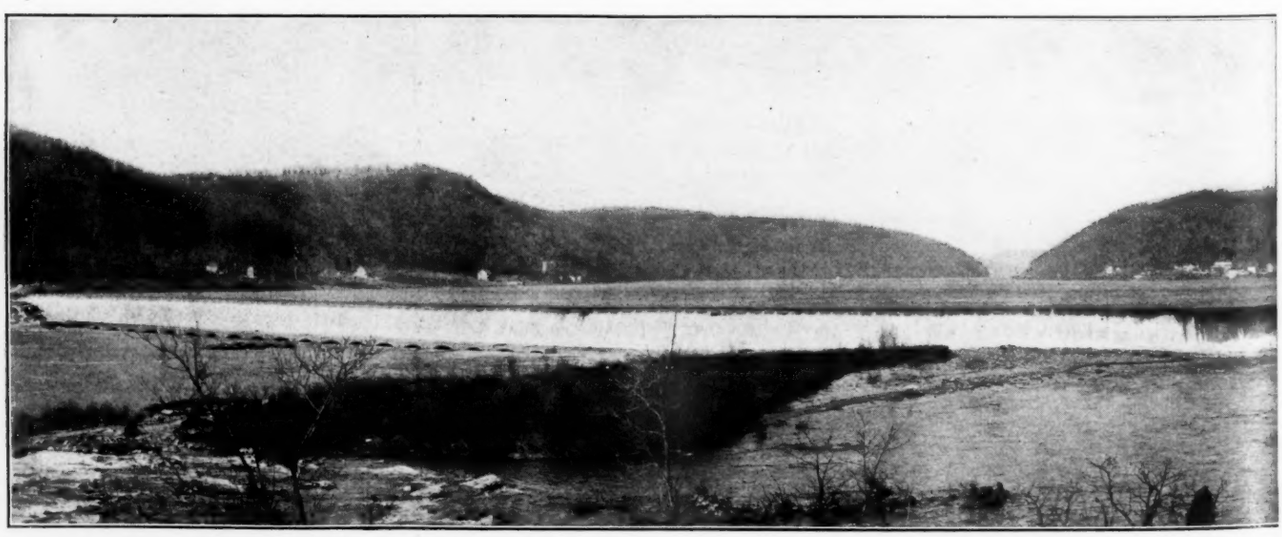


Fig. 2. Panorama of Dam and Power House, Showing Deflecting

low stop logs, consisting of steel skeleton frames were provided for each opening. To divert the flow of water and allow of filling in the spaces between sections these stop logs were lowered into the spaces and heavy canvas curtains made to cover the upstream side of the framework. Lengths of large hose were placed at the sides and bottom and then inflated with air; the space then became dry. It is estimated that over $400,000 was saved by the use of these stop logs instead of building coffer-dams for the purpose.

After the necessary coffer-dams were built, first one from the Lancaster or east shore and then one from the York or west shore, a construction bridge was built on the down-stream side of the dam. It was thought that the flood waters of the river would undoubtedly carry away the usual temporary trestle work used for construction purposes, hence the use of the construction bridge. The Lancaster end of the bridge was 1100 ft. long, arch form, with 40-ft. spans, and had a roadway 50 ft. wide. The York end of the bridge was of the same design but 900 ft. in length.

Huge traveling-boom cranes ran on tracks on this construction bridge to deposit steel and concrete. Interchangeable steel forms were used in the construction of the dam.

An idea of the rapidity with which the work was done and the volume of material handled is gained from the fact that a concrete-mixing plant was built with a mixing capacity of 2000 cu.yd. every 10 hr. and a storage capacity of 14,000 cu.yd. for concrete material. This plant was later destroyed by fire.

The flow of the river at the head of the dam is westward, while the power house is on the east shore. This flow carries ice away from the power house. However, a wing dam, right background, Fig. 2, having three submerged arches, through which water enters the forebay was built at right angles to the main dam and, with the aid of floating booms, diverts ice into the main stream where it is carried away. The wing dam terminates at a meter house containing a meter for recording the height of water in the forebay. Two ice chutes in the power house and three on the shore end permit of the disposal of ice. A deflecting wall, separating the main stream from the tailrace, serves as a walk to Piney Island (right foreground, Fig. 2), where are located the first transmission-line towers and the arc-extinguisher equipment.

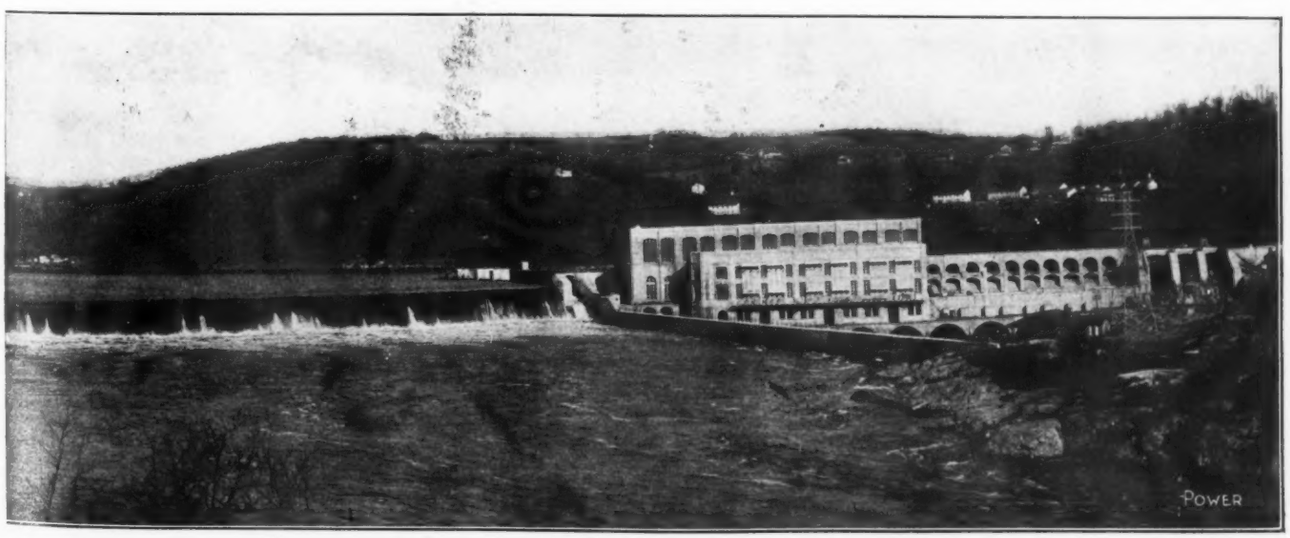
The tailrace, Fig. 3, is a natural one throughout its entire length of two-thirds of a mile. It is formed by the east shore of the river and Piney Island, also a few other smaller islands. The spaces between the islands were closed by cribs and rock fills. About 150,000 cu.yd. of rock were removed at the lower end of the tailrace to obtain a head of 53 ft.

FIG. 3. NATURAL TAILRACE

The fishway, extreme right, Fig. 2, is in two sections, each 8 ft. 10 in. wide, 254 ft. long, with a slope of 1 to 4. Each section contains wooden barriers every 6 ft. to break the velocity of the flow and to form eddies where the fish may rest.

THE POWER HOUSE

The generator house, i.e., that part of it below the rails of the 100-ton crane (see Fig. 4) and also the gate house are of solid concrete. The walls of the transformer



WALL, TAILRACE ARCHES, FISHWAY AND TOP OF CONSTRUCTION BRIDGE

house are of reinforced concrete. The power house was originally designed to provide space for ten 13,500-hp. turbines. The concrete superstructure is already in place, so that to install more units all that is necessary is to run in the parts on a spur track, erect the unit, and add the necessary length to the power house.

As shown in the transverse section, Fig. 5, the main generating room is in the center with the rheostat gallery and gate house on the right and the transformer house on the left. A machine shop is located at the rear of the transformer house.

Turbines

Although space for 13,500-hp. turbines was provided for in the design of the plant, the present owners found that units of 17,500 hp. capacity could be installed without altering the pits. This was done with unit No. 6 and the seventh unit, which is also of 17,500 hp. is now being installed; each of the first five units are of 13,500 hp. capacity. The first four units were originally connected to 7000-kv.-a., three-phase, 25-cycle, 11,000-volt generators, but the present owners rewound units Nos. 1 and 2, increasing their capacity to 10,000 kv.-a. each.

As shown in Fig. 5, the turbines are provided with double draft tubes. This is necessary because of the varying height of the tail water. The penstocks, wheel chambers and draft tubes are of concrete. The recent high water, reaching a height of 13 ft., going over the dam on Mar. 29, reduced the head by 10 ft., but did not cause any trouble at the plant.

The turbines each have two wheels on a single shaft, the load of 410,000 lb. being carried at some of the turbines by roller bearings, and at others by thrust bearings known as the Kingsbury bearings. This bearing is described and illustrated on page667of this issue.

The turbine rotors are so heavy that it is not desired to lift them with the 100-ton crane provided in the generator room. For this purpose a high-pressure, double-acting pump mounted on a truck is fitted so that the suction end may be quickly connected to the oil reservoir of the thrust bearing; the discharge is connected to the oil pipe discharging directly into the bearing, which serves as a hydraulic jack. By operating the pump with compressed air the rotor may be lifted and when raised may be held by a rachet arrangement at the side of the casing. By mounting the pump on a truck it may be easily moved to any turbine.

Control of Main and Exciter Turbines

There are two 250-volt, 400-kw., compound-wound, interpole-exciter units, running at 240 r.p.m., and one 250-volt, 500-kw., compound-wound, interpole unit, running at 750 r.p.m. The first two are driven by water turbines of 1000 hp. each at 240 r.p.m. with 53-ft. head. The third unit is driven by a synchronous motor of 750 hp., 25 cycles, three-phase and 10,500 volts; Fig. 6 shows the exciter units.

As there are six main units and two turbine-driven exciters there are thus eight governors which are of the gear-driven, double-floating-lever type. The actuating power system for the governors is most complete, there being five motor-driven, six-stage centrifugal pumps and one turbine-driven triplex pump. The pump room is located at the left of and below the generators. The floor has a transverse slope of ¼ in. to the foot toward a 10-in. gutter to provide for drainage. There are two 5-in. single-stage centrifugal-drainage pumps driven by direct-current vertical motors of 50 hp., 220 volts, 750 r.p.m. The actuating power system for the governors is laid out as follows:

The five motor-driven centrifugal pumps and the one turbine-driven triplex pump take water through a 14-in. line from the forebay and deliver at 300-lb. pressure into a 10-in., 8-in. and 5-in. pipe line leading to three steel accumulator tanks on the turbine floor. An air compressor driven by a 7.5-hp., 220-volt, direct-current motor running at 1100 r.p.m., furnishes air to these accumulator tanks to create a cushion effect in the system. The

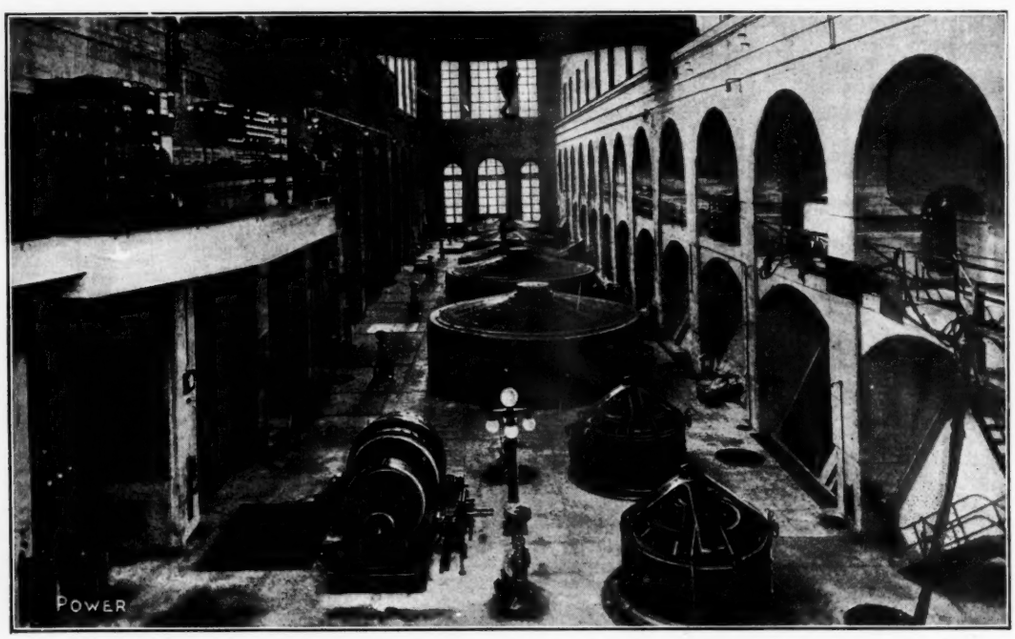


Fig. 4. Interior of Generator Room

compressor also furnishes air to brakes on the turbine shafts. From these tanks the high-pressure water is led to the cylinders operating the wicket gates controlling the flow of water to the turbines, the admission and release of water from these operating cylinders being controlled by the turbine governors, the speed of which varies as the speed of the turbines. The operating cylinders are much the same as a steam-engine cylinder and are pro

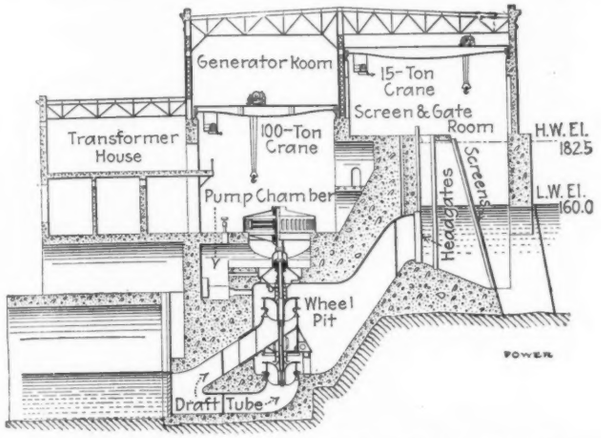


Fig. 5. Transverse Section of Power House

vided with an index pointer moving over the face of a graduated gage which indicates the percentage of gate opening. As the water used in this high-pressure system becomes quite warm it is cooled after being discharged from the operating cylinders into the "sump" tanks; the cooling water passing through brass-welded coils submerged in the "sump" tanks, of which there are three.

To avoid recourse to hand control of the operating cylinders, two of the five motors driving the 5-in., six-stage centrifugal pumps in this system are of the induction type, 300 hp., three-phase, 25 cycles, 665 amp. per terminal, running at 1440 r.p.m. The other three are direct-current motors, two being of 150 hp., 220 volts, running at 1530 r.p.m., and the other is 100 hp., 220 volts, 375 amp., running at 1700 r.p.m., and is direct connected to a six-stage centrifugal pump capable of discharging 450 gal. per min. at a 300-lb. head.

As mentioned before, there is a triplex pump, turbine driven, also connected to this system. It is thus realized that if the alternating-current supply fails, the direct-current motors may be started, and *vice versa*. It is possible also to maintain the pressure with the turbine-driven triplex pump. Three of the high-pressure service pumps are connected for pumping water out of the pump room in case it should be flooded, and for delivering water for house purposes to the dwellings on the hill, right, Fig. 2, occupied by the working force at the plant.

Lubrication System

In this system the oil flows from two storage tanks, each of 3000 gal. capacity, located in the gate house and connected to a header located on the wall of the passageway where the wheel-gate-operating pumps are situated. This header is connected to the storage tanks by duplicate pipe lines, so that in case of a breakdown in one storage tank, the other may be placed in commission, and in this way the system is insured against a shutdown.

From the above header, each generating unit is fed by separate pipe lines. The dirty or used oil is collected in a pipe header and flows by gravity to the filter. This filter has a capacity of 125 gal. per min., is equipped with cooling coils, and also has a storage capacity of 4700 gal., which allows the oil to be run to the filter in case of accident to a storage tank.

In this filter the oil is cleansed and cooled and from here is pumped to the storage tanks by motor-driven centrifugal pumps. By means of a bypass in the piping system, oil from these pumps may be placed directly into the header which supplies oil to each generating unit.

Sight-feed indicators, with electrical attachment, are placed in each feed line, so that in case of an accident to the feed line, the operator is apprised by an annunciator which is connected to these sight flows. Thermometers are placed in the storage tank and also at each outlet of each generating unit.

Electrical Equipment

The exciters deliver current to duplicate sets of busbars, each set taking care of one-half the plant. The voltage is regulated automatically by a regulator mounted on the switchboard. This regulator can handle one, two or all three exciters. Provision is also made for a duplicate regulating system for operating the plant as two separate divisions of units.

Transformers

The transformer house provides space for 10 three-phase transformers for stepping up the voltage from 11,000 to 70,000 volts. The transformers are rated for a

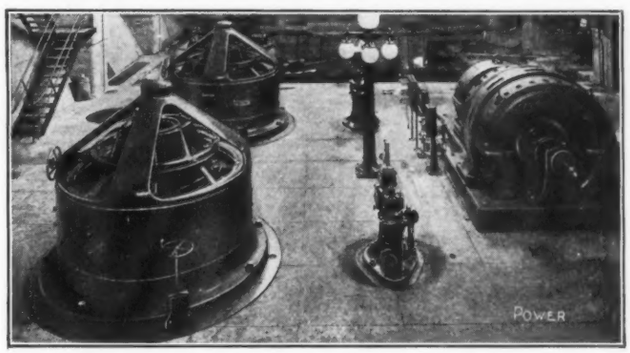


Fig. 6. Showing the Three Exciter Units

maximum of 300,000 volts. Seven transformers are now installed, five being of 10,000 kv.-a. capacity, two of 7500 kv.-a. capacity. The first 10,000-kv.-a. transformer was the largest ever built at the time of its installation. They are elliptical, 15 ft. 11 in. long, 8 ft. 8 in. wide and 16 ft. high.

The windings are delta connected on the low-tension side and star connected on the high-tension side. The neutral is grounded through resistance "stacks" connected in series. All transformers are of the shell type mounted on wheels so that they may be run out under the 100-ton Morgan crane in the generator room.

The smaller transformers are oil cooled. The larger ones are oil insulated and internally water cooled. The water gravitates to the transformers, passing through them to coils in concrete tanks under the arches of the transformer house. The cooling water is taken from the forebay. The covers are equipped with vents, consisting of lead gaskets which break when the pressure gets too

high in the tank. The high-tension terminals are brought out of the tanks through oil-cooled bushings.

The substation at Baltimore has five 10,000-kw. transformers to step down the line voltage of 60,000 to 13,200. These transformers are oil insulated and externally water cooled. The cooling system consists of two motor-driven centrifugal pumps, each of 350 gal. per min. capacity. One of these pumps takes water from an artesian well and discharges it to a 10,000-gal. tower elevated 65 ft. above the transformer bases. After gravitating through the transformers, to a cistern, the other pump lifts the water to the roof where it is prepared for rapid cooling by passing through spraying nozzles. It then runs down to mix with the colder well water, after which the cycle is repeated.

Besides the main transformers in the plant there are two station-service transformers, circuits 11,000 volts to 230 volts. A 300-kw. testing transformer of 300,000 volts maximum voltage, excited by a step-down transformer of 200 kw. capacity, 11,000, 2200 volts is also provided. The testing load is obtained by a water rheostat designed for 15,000-kw. continuous load. Another transformer, 150 kv.-a. capacity, 11,000 to 250 volts, is used for lighting Holtwood (name of settlement at plant) and for the construction plant.

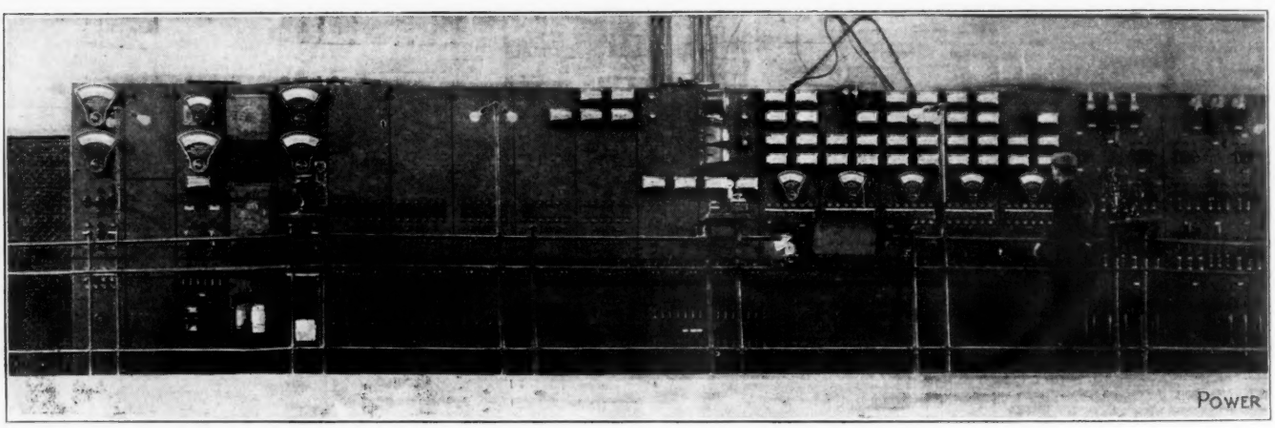


FIG. 7. BENCHBOARD, SHOWING PANELS IN USE AND FOR FUTURE INSTALLATIONS

BUSSES, SWITCHBOARDS AND STORAGE BATTERIES

The station is provided for six outgoing, 70,000-volt, 300-amp. lines. Provision for six outgoing, 11,000-volt, 300-amp. local feeders also obtains.

The busses are of hollow-copper tubing. Each generator delivers current either to the low-tension bus or step-up transformers or to both at the same time. Thus there are ten groups of oil switches, each group having a generator switch, a transformer switch and a tie switch. Disconnecting switches are installed on each side of every circuit-breaker so that they may be cleaned and inspected with safety.

The feature of the busbar system is that the high-tension busses are in duplicate, sectionalized at the center and tied together at the ends by oil circuit-breakers. This makes a complete ring bus capable of being operated in one, two, three or four sections. Any of the six lines and any of the ten transformers may be connected to any of the ten high-tension busbars by selective oil switches.

The entire plant is controlled from a benchboard, Fig. 7, on a gallery overlooking the generating room. The generator rheostats on the gallery opposite their respective generators are motor operated, as are the field circuit-breakers. The exciter board is on the rheostat gallery and contains panels for each of the three exciters. Five other panels provide for service to motors for cranes, pumps, headgate hoists, etc. Each individual circuit is provided with automatic circuit-breakers, voltmeters and ammeters. All switchboards are of natural-oiled slate.

The main control board contains ten sets of panels for generators and transformers. The benchboard contains one control switch for each generator oil switch, transformer oil switch, low- and high-tension side, generator-field rheostat and governor control. The usual red and green lamps are provided in each control-switch circuit. Both the high- and low-tension bus systems are reproduced in mimic on the benchboard. The control switches for the signal system in the generator and pump rooms are also mounted on the vertical panels. An intercommunicating telephone system is also installed in the plant.

On the rear panels of the benchboard facing the switch-room are mounted the generator intergrating watt-hour meters; the definite time-limit relays protecting the generators; the inverse time-limit relays protecting transformers, outgoing lines and feeders, and instantaneous relays protecting the station-service circuits and testing equipment circuits.

STORAGE BATTERIES

In the transformer house is a small, glass-jar cell, storage battery used in emergencies to supplement the 250-volt, direct-current supply to circuit-breakers, oil switches, etc. A wooden-tank cell, battery of 142 cells, with 37 end cells, is installed in a compartment in the gate house. This battery is expected to carry the entire excitation load for one hour.

TRANSMISSION LINES

The right-of-way to Baltimore is 100 ft. wide and 40 miles long. The lines are in duplicate, each set having three cables, the current being three-phase. The cables, 300,000 circ.mils in size, are of aluminum and suspended from the steel towers by strain insulators where long spans or angles occur and by suspension insulators in straight-away work. There are 415 towers, ranging in height from 63 to 135 ft. The longest span in the line and one of the longest in the world is 1800 ft., between

PRINCIPAL EQUIPMENT McCALLS FERRY POWER PLANT

Equipment	Type	Use	Kw.	Volts	Amp.	Cycles	Phase	R.p.m.	Head	Hp.	Manufacturer
5 Turbines	Vertical	Generator drive	...	...	...	..	...	94	53	13,500	I. P. Morris Co.
2 Turbines	Vertical	Generator drive	...	...	...	..	...	116	53	17,500	I. P. Morris Co.
2 Turbines	Vertical	Exciter drive	...	...	...	..	...	240	53	1,000	I. P. Morris Co.
4 Generators	Alternating, vertical	Light and power	10,000	11,000	525	25	three	94	..	...	General Electric Co.
1 Generator	Alternating, vertical	Light and power	7,500	11,000	392	25	three	94	..	...	General Electric Co.
2 Generators	Alternating, vertical	Light and power	12,000	11,000	650	25	three	116	..	...	Westinghouse Electric & Mfg. Co.
2 Generators	D. C. Vertical	Exciter service	400	250	1600	..	...	250	..	...	Westinghouse Electric & Mfg. Co.
1 Generator	Motor generator set	Exciter service	500	250	2000	..	...	750	..	...	General Electric Co.
	Synchronous										
1 Motor	Motor generator set	Exciter service	...	10,500	31.8	25	three	750	..	750	General Electric Co.
1 Switchboard	Benchboard	Remote control	...	...	...	..	...	...	..	...	General Electric Co.
3 Transformers	Water cooled	Voltage step up	10,000	11,000 / 70,000	...	25	three	...	..	...	General Electric Co.
2 Transformers	Water cooled	Voltage step up	7,500	11,000 / 70,000	...	25	three	...	..	...	General Electric Co.
2 Transformers	Water cooled	Voltage step up	10,000	11,000 / 70,000	...	25	three	...	..	...	Westinghouse Electric & Mfg. Co.
1 Transformer	Oil cooled	Voltage step down	...	11,000 / 2,200	...	..	...	...	..	...	General Electric Co.
1 Transformer	Oil cooled	Testing	...	Maximum 300,000	...	..	...	...	..	...	General Electric Co.
1 Transformer	Oil cooled	Voltage step down	200	11,000 / 550	...	..	...	...	..	...	General Electric Co.
1 Transformer	Oil cooled	Station service	...	11,000 / 200	...	..	...	...	..	...	General Electric Co.
1 Storage battery	Glass jar	Station service	...	...	...	..	...	...	..	...	Gould Storage Battery Co.
1 Storage battery	"Chloride accumulator"	Emergency	...	...	...	..	...	...	..	...	Electric Storage Battery Co.
2 Motors	Direct current	Accumulator pump drive	...	220	375	..	...	1700	..	100	Westinghouse Electric & Mfg. Co.
2 Motors	Induction	Accumulator pump drive	...	...	665	25	three	1440	..	300	Westinghouse Electric & Mfg. Co.
2 Motors	Direct current	Accumulator pump drive	...	230	540	..	...	1530	..	150	General Electric Co.
2 Motors	Direct current	Drainage pump drive	...	220	190	..	...	750	..	50	Westinghouse Electric & Mfg. Co.
2 Motors	Direct current	Oiling system	...	230	37.7	..	...	1700	..	10	Westinghouse Electric & Mfg. Co.
1 Motor	Direct current	Air compressor drive	...	220	28	..	...	1100	..	7.5	National Brake & Electric Co.
				Stage		Size			Pressure		
2 Pumps	Centrifugal	Oiling system		single		2½ in.					Henry R. Worthington Co.
2 Pumps	Centrifugal	Drainage system		single		4 in.					I. P. Morris Co.
5 Pumps	Centrifugal	Accumulator pressure		6		5 in.			350 lb.		I. P. Morris Co.
1 Pump	Triplex	Accumulator pressure		..		3 in.			350 lb.		Deane Steam Pump Co.
1 Air compressor	Motor driven	Plant supply		..		....			350 lb.		National Brake & Electric Co.
Lubrication system											Peterson Engineering Co.
2 Cranes											Morgan Engineering Co.

Piney Island and the York shore of the river. Horn gap lightning arresters are provided where the lines leave the station. On Piney Island there is an elaborate arc-extinguishing equipment to minimize the troubles due to electrical storms. This equipment is shown in Fig. 8. The towers carry a private telephone line connecting the power plant, patrol stations, substations, and the steam plants of the Baltimore Gas & Electric Co., and United Railways Co. of Baltimore which act as standby stations for the McCalls Ferry plant.

The transmission line to Lancaster, Penn., is nearly completed and it is expected that at least 10,000 kw. will be sent over these lines this coming June.

The present plant with its transmission lines, substations, etc., cost nearly $16,000,000.

The engineering department of the Pennsylvania Water & Power Co., with offices at Baltimore, Md., is composed of J. A. Walls, chief engineer; F. A. Allner, general superintendent; A. Benson, assistant chief engineer; P. L. Smith, superintendent of operation; A. Bang, chief testing engineer; W. P. Baker, superintendent of installation, and T. C. Stabley, chief operator.

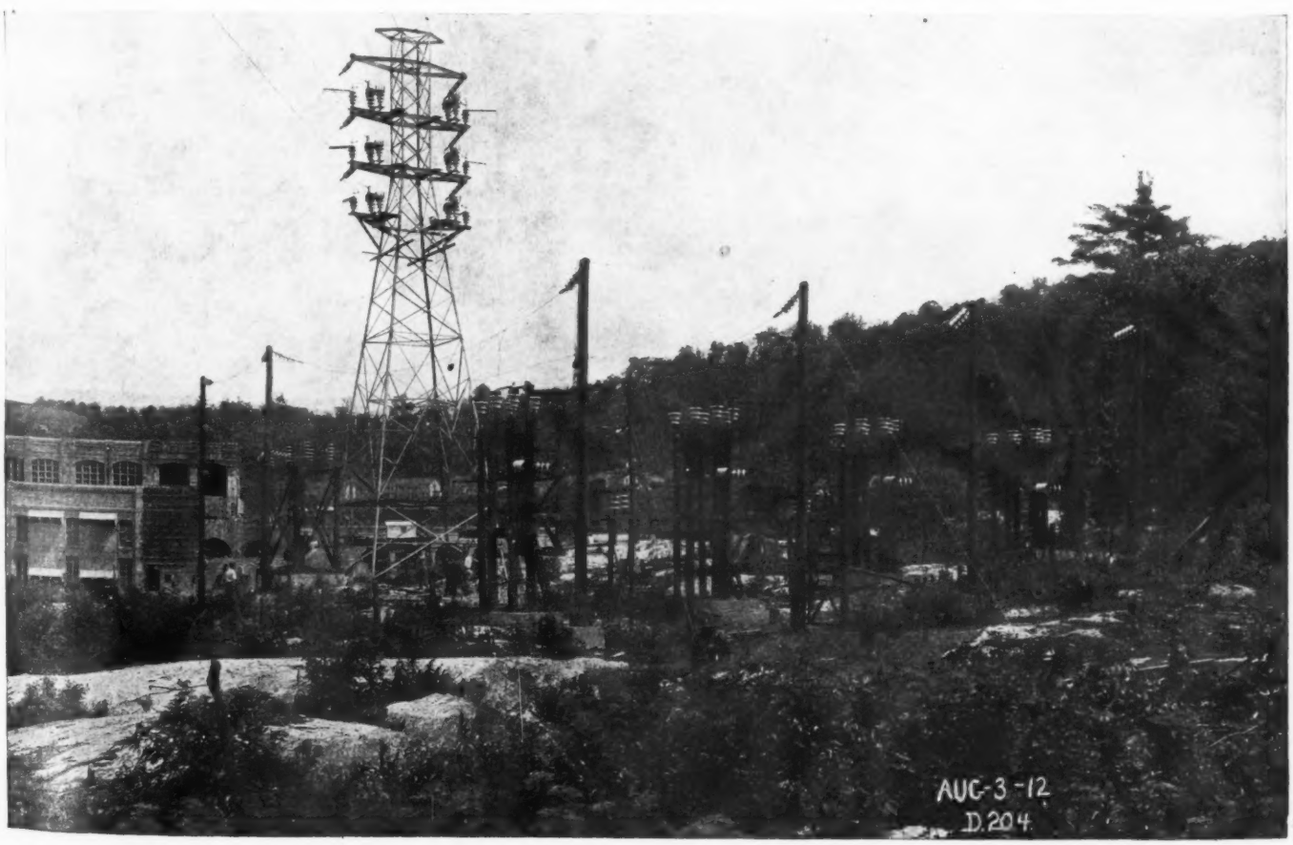


FIG. 8. ARC-EXTINGUISHER EQUIPMENT ON PINEY ISLAND

Furnace for Horizontal Tubular Boiler

By R. Cederblom

SYNOPSIS—The author hopes to obtain complete combustion by passing the gases through a perforated arch like that in the Broman furnace (see Power, *Feb. 4, page 171), and then get best results by the scrubbing action of the gases on the heating surface. The scrubbing effect is produced and made intense by passing the gases, by induced draft, through narrow passages between the shell and walls or bridges.*

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Every experiment along the line of increased evaporation in boilers shows that it is a matter of getting the hot gases in close contact with the metal and making them sweep over the surface at a high velocity to give a scrubbing action. The boiler must be built to give rapid and positive circulation to the water so as to take up the heat as fast as it is applied.

With return-tubular boilers as ordinarily built and with a common setting, the results would probably not be good, should we try to double the capacity by doubling the grate area. The circulation in this type of boiler is not as good as in a water-tube boiler, also the 4-in. fire tubes—the usual size—are not as effective as might be desired, prob-

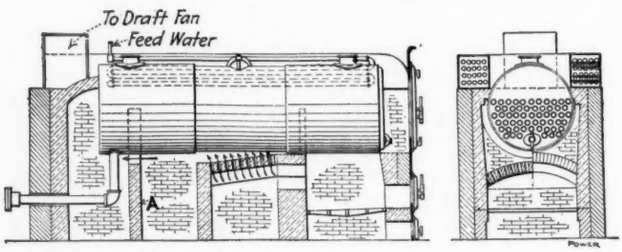

Fig. 1. Showing Large Combustion Chamber

ably because of such large diameter that part of the gases pass through without making good contact with the metal, thus increasing the stack temperature when trying to force this type of boiler. With some modification, however, in the way of both boiler and furnace construction, as good results could be had from a return-tubular boiler as from any other kind, and if so this type of boiler would have many advantages over the water-tube construction.

The ordinary conditions are 10 or 12 sq.ft. of heating surface per boiler horsepower, which means about 3300 B.t.u. absorbed per hour per square foot of surface, and with the usual rating of one to forty and an evaporation, of, say, about 7 lb. of water per pound of coal, we have 20 lb. of coal burnt per sq.ft. of grate. This is far from the 48,000 B.t.u., or 80 or 100 lb. of coal burned per square foot of grate which has been accomplished in recent experiments and with as good results in regard to efficiency as under the ordinary slow rate of combustion and evaporation.

In a locomotive boiler the firebox generally evaporates from 30 to 40 lb. of water per hour per square foot of surface, and there is no reason why the lower sheets of a return-tubular boiler should not be as effective and doubtless are, if the heat is applied in the right way. In the ordinary setting, however, this is not done, as a large per cent. of the gases never gets in contact with the shell. Where smoke ordinances are in force, the biggest part of this surface is often made ineffective by brick arches, piers, etc., throwing the flame away from the shell instead of toward it, the flame often not coming in contact with the boiler at all until it strikes the rear head and enters the tubes.

Theoretically this should not make any difference, as there is ample surface in the tubes to take up all the heat produced by combustion, but for some reason this does not work out practically. Probably this is because the circulation around the tubes is not what it could be with proper arrangements. Also it may be due to the fire side of the tubes being more or less covered with soot. Soot seems to form more readily on the thin metal of the tubes than on the boiler plate, probably because the temperature of the tube surface is nearer to that of the water than is that of the comparatively thick plate.

What arrangement should we have for a practical ap-

Fig. 2.

Fig. 3.

Action of Water on Staggered and Straight Rows of Tubes

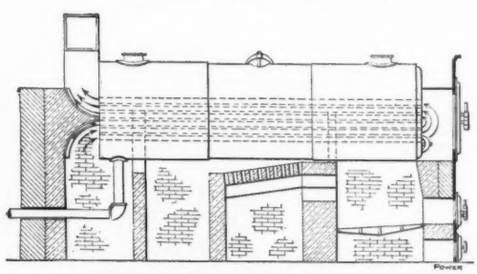

Fig. 4. Two-Pass Boiler

plication of these methods to a return-tubular boiler 60 in. by 18 ft., ordinarily rated at 100 hp. but intended for an output of 200 hp. with 50 per cent. overload if necessary?

The principal requirements are: High rate of combustion, high gas speed, close contact between gas and heating surface and as long passage as possible from the grates to the uptake.

High rate of combustion may be obtained from either forced or induced draft, but in this induced draft will be used to get high gas speed. To create this draft we must sacrifice a certain per cent. of the boiler output, but, on the other hand, the higher effieciency invariably gained by such means will often more than offset this loss.

At a rating of 200 hp., which means 6000 lb. of water evaporated per hour, and with an evaporation of 8 lb. of water per pound of coal, we have to burn about 750 lb. per hr. At 50 lb. per sq.ft. per hr., which is really a low figure with intense draft, we need about 15 sq.ft. of grate surface.

With narrow gas passages and close contact with the heating surface it is necessary to get complete combustion of the gases before they come in contact with the

boiler shell or tubes, once in contact and the temperature reduced, combustion cannot be completed, and to accomplish desired results we must, therefore, provide a proper combustion chamber.

Under the required draft conditions, neither a dutch-oven nor any of the ordinary arrangements with arches, bridges, etc., would serve the purpose, as the gases would travel at such a high velocity after leaving the bed of coal on the grates, that there would not be time or chance for thorough mixing or complete combustion before they come in contact with the heating surfaces. Under such conditions nothing but a checker work of heated bricks would do, and the only device the writer has seen so far that would promise a solution of this essential problem is the "Broman" perforated arch furnace, described in POWER, Feb. 4, page 171.

As seen from Fig. 1, this proposed setting provides a large combustion chamber without sacrificing any of the most effective part of the heating surface and brings the gases in very close contact with the shell. In passing through the numerous small openings the gases are divided up into such small volumes and brought in such intimate contact with the free air that it seems complete combustion would be the inevitable result. After complete combustion has once been accomplished the next problem is to bring the gases in as close contact with the shell as possible. For the remaining part of the shell this could be done by building two or three bridges, such as *A*, back of the oven, the top of these to conform with the curvature of the shell, the space between the bridge and boiler depending on the intensity of the draft; the higher the speed of the gases the less the space.

To obtain as long a passage as possible the boiler should be made longer than the usual standard, if space permits, and the tubes of much smaller diameter, not over 2 in.

In regard to spacing of tubes, the author believes the method of staggering them, universal 25 or 30 years ago, is the most effective when it comes to rapid heat absorbtion.

As the circulation is more or less in a vertical direction, a glance at Figs. 2 and 3 will tell at once which construction is the most effective. In Fig. 2 the body of water passing down between the tubes, strikes the hottest part of the tube below and splits up in two directions, sweeping the entire surface of the tubes. This is not the case in Fig. 3, however. Being a liquid and not subject to expansion, it cannot fill the larger space, as at *A*, if the rate of flow is uniform, and the result is poor heat transmission over what should be the most effective surface and corresponding high stack temperature.

With still higher rate of combustion, say, 80 or 100 lb. of coal per hour per square foot, it may be found advisable to have a two-pass boiler, as shown in Fig. 4, or some simple economizer arrangement made up of piping and boxed in so as to be easily blown out with steam. With proper draft there is no reason why we should not get 250 or 300 hp. out of a boiler of this size, at as high, if not higher, efficiency than is now obtained with the ordinary arrangements.

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Power Equipment of the "Aquitania"*

SYNOPSIS—The vessel is considered the queen of the Cunard fleet. She has 21 doubled-ended boilers. The turbines work on the triple-compound system, giving a great range of expansion. The steam piping is most complete. A Diesel engine-generating set on the boat deck will furnish light in emergencies.

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On Apr. 21, the new Cunard liner, "Aquitania," was launched at Clydebank, England. This vessel is 902 ft. long, 97 ft. beam, with a hull depth of 64 ft., and a displacement of 49,000 tons. It will be propelled by four screws driven by steam turbines, giving a total of 60,000 shaft-horsepower. The boilers are double ended, with a total heating surface of 139,000 sq.ft.; grate area, 3500 sq.ft., and they will operate at 195 lb. pressure. The vessel is built for 23.5 knots per hour. Fig. 1 shows the hull in course of construction.

This vessel was patterned after the "Lusitania" and "Mauretania," but new features are added, increasing the safety and general utility of the vessel. The "Aquitania" is larger in length, beam and tonnage than the "Lusitania," but is less in horsepower by 8000; less in boiler-heating surface by 19,350 sq.ft., and less in grate surface by 548 sq.ft. She is also 2.5 knots slower.

In the "Lusitania," the ratio of heating to grate surface is 36.7 : 1, and in the "Aquitania" 39.7 : 1. The ratio of indicated horsepower to grate surface is 17.14 : 1 for the "Aquitania" and 16.8 : 1 for the "Lusitania." It is thus seen that the "Aquitania" has much reserve power.

*Acknowledgment is made to the Cunard Co., and "Engineering" (London) for the information herein contained.

BOILERS

There are 21 double-ended boilers, with eight furnaces in each; the working pressure is 195 lb. per sq.in. All boilers work under forced draft, the air pressure being maintained by twenty-eight 66-in. fans, driven by 14 electric motors, one motor driving two fans.

FIG. 1. HULL DURING CONSTRUCTION

There are four boiler rooms. In each of the three forward boiler rooms, which are 78 ft. long by 60 ft. wide, are six boilers, placed three abreast, while in the aftermost boiler room, which is 42x60 ft., there are three boilers simliarly placed. In addition to the ordinary exits, there is an emergency escape from each boiler room through the deck overhead.

To each boiler room, there is a large double-elliptical funnel, the outer casings of each being 24 ft. on the major axis, by 17 ft. on the minor axis. The forward funnel is 154 ft. 9 in. above the fire grate, and 64 ft. 6 in. above the casing top. The firing platforms are clear at all times, as the ashes are expelled by machinery. In addition to these expellers, eight ash hoists are distributed throughout the boiler rooms.

Turbine-Propelling Machinery

The turbines are arranged in three engine rooms, one in each wing, and a center compartment, divided by longitudinal bulkheads. The total length of the engine room is 84 ft.

The turbine arrangement is somewhat different from that in the "Lusitania." In the latter, the system of compound turbines—one high-pressure exhausting into one low-pressure turbine—was adopted, there being two complete and separate units on each side of the center line of the ship. In the "Aquitania," however, the turbines are arranged to work on the triple-compound system, which gives a greater range of expansion, and, consequently, a higher economy. The port-wing shaft is rotated by the high-pressure turbines, which exhaust into an intermediate-pressure turbine on the starboard-wing shaft, the steam goes thence through a pipe leading into two low-pressure turbines mounted on the inner shaft. The steam-piping arrangement in connection with the operation of this triple arrangement is such that the high-pressure turbine may be cut out at will in the event of an accident, the steam passing direct from the boilers to the intermediate-pressure turbine on the starboard shaft.

In the event of its being necessary to cut out the intermediate-pressure turbine, the boiler steam will pass to the high-pressure turbine on the port-wing shaft, and thence to the low-pressure turbine on the port inner shaft, while the starboard low-pressure turbine could be driven by boiler steam, passed direct through the lead provided for the running of the low-pressure turbine when maneuvering. If the low-pressure turbine on the starboard inner shaft should be placed out of action, the high-pressure, the intermediate-pressure and the other low-pressure turbine could be operated, a blank flange, provided for the purpose, being fitted in the connection between the intermediate-pressure turbine and the starboard low-pressure turbine. Thus, if any one turbine is disabled, the other three shafts can be worked with little loss of time in making the changeover. Considering the capacity for overload of all the turbines, the speed of the ship need not be greatly reduced. The turbine arrangement is considerably better than that of the twin-screw ship, where, if the machinery on one side breaks down, the ship can only be propelled by the machinery on one side of the center line.

Main Steam Piping

As on all large ships, there are two main steam pipes between the boiler and the engine room. Both are in direct communication with the main line of piping at the forward end of the engine room. In this line are interposed separators, the usual stop valves, these being so located that the steam may pass directly into the high-pressure turbine or, alternately, directly to the intermediate turbine, while an independent line of piping is led to each of the two low-pressure turbines, the main object being to utilize these pipes for maneuvering in the harbor or at docks. At sea, and whenever required, all four propellers can be utilized for astern working, each shaft being fitted with an astern turbine. On the wing

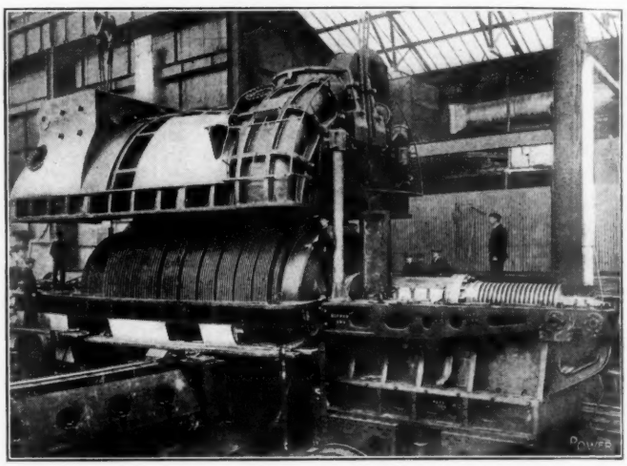

Fig. 2. Low-Pressure Ahead and Astern Turbine of "Aquitania"

shaft are mounted high-pressure astern turbines abaft and separate from the ahead turbines and to these there are direct lines of steam pipes.

Low-pressure astern turbines are arranged in the same casing as the low-pressure ahead turbines on both inner shafts. The port astern high-pressure turbine passes steam directly to the low-pressure astern turbine on the port inner shaft and the starboard astern high-pressure turbine to the low-pressure astern turbine on the starboard inner shaft. All steam-admission or maneuvring valves and the bulkhead valves are operated by levers from a platform on which the engineer on watch must stand. He, therefore, has full control of the engine room. On the high-pressure turbine-exhaust line to the intermediate-pressure turbine a 53-in. change valve is introduced, by which the high-pressure ahead-turbine exhaust can be passed either to the intermediate-pressure turbine or directly to the low-pressure ahead turbine.

A 66-in. shutoff valve is fitted in the line of piping between the intermediate-pressure turbine and the low-pressure turbine, so that, when this valve is closed, the intermediate-pressure turbine exhausts through the starboard low-pressure ahead turbines only, and the high-pressure turbines exhaust into the low-pressure turbine on the port shaft only. This means that, should the low-pressure turbine on the port inner shaft get out of order, the ship could be propelled by the high-pressure turbine on the port-wing shaft, the intermediate-pressure turbine on the starboard-wing shaft and the low-pressure turbine on the starboard inner shaft. There is a separate boiler-steam connection to the intermediate-pressure turbine so that, if the shutoff valve on the intermediate-pressure exhaust pipe is closed, the intermediate-pressure turbine and the

low-pressure turbine on the starboard side can be worked independently of the high-pressure turbine and the low-pressure turbine on the port side.

Under these conditions, the port shaft may be working ahead while the starboard shafts are running astern, or *vice versa*. The high-pressure astern turbine is fitted abaft the high-pressure ahead turbine on the port shaft. These two turbines, when coupled together, make a total length of 63 ft. The bearing block between these turbines is fixed, the forward and aft ends being free to take up the expansion. The high-pressure astern turbine fitted abaft the intermediate-pressure turbine on the starboard-wing shaft is similar to that on the port-wing shaft. The main eduction, or exhaust pipe to the condenser of the low-pressure ahead and astern turbine is rectangular and 15 ft. wide by 6 ft. high. Fig. 2 shows one of the low-pressure ahead and astern turbines with the upper part of the casing removed, showing the rotor. The rotor of this turbine is shown in Fig. 3, and weighs 130 tons. The blades of the turbines are fitted in segments on the rosary principle, and are sharpened away at the points like a gouge.

On the after-turbine coupling, on each line of shafting, a motor-driven turning gear is fitted. All the casing covers have motor-driven lifting gears, the lifting beams being built into the ship and supported by the guide columns at both ends of the casing. The tunnel shafting is hollow and divided into lengths of about 25 ft. each. There are two bearings to each length. All the shafting and the rotor drums were made by John Brown & Co. The rotor drums are of forged steel and are sprung out from an ingot previously trepanned. The turbine casings

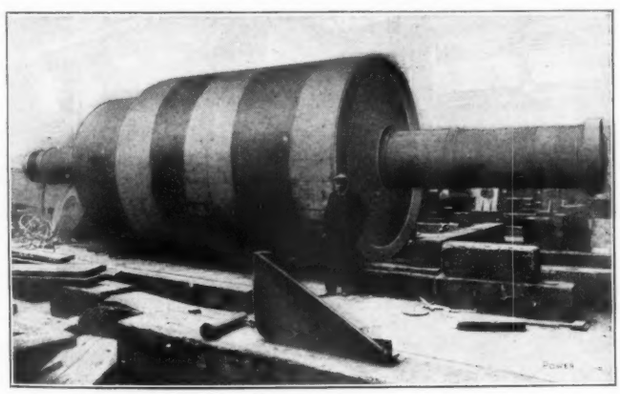

FIG. 3. ROTOR OF ONE OF THE TWO LOW-PRESSURE AHEAD AND ASTERN TURBINES, BLADING IS COVERED

are of cast iron. Each low-pressure turbine exhausts into a Weir "Uniflux" condenser. Two 30-in. discharge pipes from two centrifugal pumps supply the circulating water to each condenser.

The forced-lubrication system is very complete, there being six main forced-lubrication pumps in the center engine room, and, in connection with these, are the necessary strainers and coolers. All the tunnel blocks have forced-lubrication connections.

Each wing of the engine room contains two evaporators, each of 75 tons capacity per 24 hours.

ELECTRICAL INSTALLATION

The generating machinery for the electrical installation will consist of four British Westinghouse Co.'s impulse turbines, each driving a 225-volt, 400-kw., three-wire direct-current generator at 1500 r.p.m. The current on each side of the circuits will be balanced or compensated for by a static transformer in conjunction with slip rings on each turbo-dynamo. In addition to the main generators, a Mirrlees Diesel oil engine driving a 30-kw. Westinghouse generator will be placed in a house on the boat deck and will be available for emergency purposes.

There will be a total of about 200 motors, ranging in horsepower from 60, for the stokehold-fan motors, to ¼ hp. All elevators, lids, winches, etc., will be motor driven, for lighting the ship, about 7000 electric lamps will be installed. As far as is practicable, these will be of the metallic-filament type.

REFRIGERATION PLANT

The refrigeration plant will be used solely for the cuisine department, as no refrigerated cargo will be carried. A compound duplex refrigerating machine with two CO_2 compressors, two independent evaporators, duplex drying pumps and circulating pumps are being fitted to cool the many large compartments in which the ship stores are carried. The "Aquitania" and its turbines were built by John Brown & Co., Sheffield, England.

Japanese as Electrical Manufacturers

It is the ambition of Japanese engineers to make their country the workshop from which a great part of Asia will draw its requirements in respect of electrical and other machinery, declares the London *Times*, and it does not appear to be realized by European manufacturers that already the diligent imitative talent and the energetic enterprise of the Japanese have established important works of this character.

There is no sign as yet that Japan will contribute anything toward the progress of engineering science and invention, and the protective policy aims rather at providing the means whereby the new ideas of European and American engineers may be readily adopted as soon as their value is proved. For repetition work the low cost of Asiatic labor may or may not become a powerful competitive influence, but as there appears to be no reason why nearly all the generating and distributing electrical plant and apparatus needed for the Japanese home market should not be manufactured locally, the attention of outsiders may preferably be directed in the near future to the prospects on the mainland.

China has already made a start with engineering works in connection with the railways, and it will perhaps be necessary before long for Western enterprise to come to a decision as to whether financial and commercial control should be acquired of the infant electrical factories that will come into being.

These new publications are announced by the Bureau of Mines and may be had by addressing the Director, Bureau of Mines, Washington, D. C., and ordering by number: Bulletin 48. Selection of explosives used in engineering and mining operations, by Clarence Hall and S. P. Howell. 50 pp., 3 pls., 7 figs. Bulletin 55. The commercial trend of the gas producer in the United States, by R. H. Fernald. 92 pp., 1 pl., 4 figs. Bulletin 62. National Mine-Rescue and First-Aid Conference, Pittsburgh, Penn., Sept. 23-26, 1912, by H. M. Wilson. 74 pp. Technical Paper 38. Wastes in the production and utilization of natural gas, and means for their prevention, by Ralph Arnold and F. G. Clapp. 29 pp. Technical Paper 48. Coal-mine accidents in the United States, 1896-1912, with monthly statistics for 1912, compiled by F. W. Horton. 72 pp., 10 figs.

Engineer's Annual Report

By C. T. McChesney

It is an excellent practice to gather yearly all the statistics and general data available relating to power-plant operation, and formulate them into a general report, using only such facts and figures from the weekly reports as are of most importance to a yearly operating statement.

It is the business of the chief engineer to undertake this work, so that his employers may annually have a statement of results for comparison with previous years, comparison with plants of approximately similar size and as a guide for future expansion and endeavor.

First, the report should contain a brief summary of the power-plant equipment, as, for instance:

Boilers:

4 Horizontal-tubular boilers, shell 54 in. x 14 ft. Built 1897. Insured for 100 lb. pressure.
1 Chimney, 56 in. diameter x 110 ft. high.

This tabulation is to be carried through all departments. It will be found that information thus accumulated and set forth will frequently prove useful. It is well to start with the engine-room units by designating them by numbers, location or use. Thus:

Unit No. 1. Blank Co.'s automatic,
16x18 in., 250 r.p.m., directly connected to
125-kw. X X generator.
Piston rod 2½ in. diameter.
Hp. = 3.92 × mean pressure.

It is assumed that weekly indicator diagrams have been taken from each unit. Representative diagrams should be selected and incorporated in the report. They will disclose the nature of the valve setting, and give an idea of the back pressure on the engine, vacuum maintained, loss of pressure in the steam line and a hint as to the tightness of the valves and pistons. Explanatory notes may be written on the diagrams regarding the condition of the valve-gear, etc.

Results of Tests

If weekly power determinations have been made, they may be stated about as follows:

Department.....Unit No. 1

Date	Sets of Cards	Indicated Horsepower	Load
1—2—12	6	200	Machine or switchboard readings.

An abbreviated statement of boiler evaporation or capacity tests should be incorporated in the report, as follows in an assumed case:

BOILER TESTS AT BUILDING A

Trial No.	100
Duration, hr.	10
Steam-gage pressure, lb.	75
Draft at damper, in.	0.40
Temperature of feed water, deg. F.	182
Temperature of chimney gases, deg F.	480
Kind of coal used	Bituminous
Moisture in coal, per cent.	3
Wet coal used, lb.	10,000
Dry coal used, lb.	9,700
Dry ash and refuse, lb.	850
Dry ash and refuse, per cent.	8.8
Dry combustible, lb.	8,850
Water evaporated, lb.	90,000
Water evaporated at and from 212 deg. F. per pound of dry coal, lb.	9.83
Water evaporated per lb. of combustible, lb.	10.80
Boiler horsepower	280

Note: In calculating the foregoing boiler trial, let
t = Temperature of feed water, deg. F.;
H = Total heat of steam at the boiler pressure above 32 deg. F.;
W = Weight of water actually evaporated.

Then the equivalent evaporation from and at 212 deg. F. equals

$$W = \frac{H - (t + 32)}{965.7}$$

The percentage of ash equals the weight of ash multiplied by 100 and divided by the total weight of dry coal used.

A summary of the total amounts of raw materials used in the operation of the plant for the year, and their costs, together with labor and wages should also be tabulated as assumed herewith.

Thus:

Power Dept. of Bldg. A

Year	1910	1911
Quantities:		
Days mill ran	300	300
Boiler hp.	265	280
Engine hp.	185	200
Kind of coal used	Pocahontas	Bituminous
Coal used, tons	2000	1900
Cylinder oil, gal.	200	190
Machine oil, gal.	225	210
Costs:		
Total for coal, $2.90 per ton	$5,800	$5,510
Ash removal (25c. per ton)	45	42.75
Cylinder oil (35c. per gal.)	70	66.50
Engine oil	68	65
Waste, packing and other supplies	100	100
Boiler compound	50	25
Boiler insurance per year	15	15
Fire insurance	20	20
Repairs	390	400
Taxes on power plant	45	45
Engineers, firemen and coal passers, wages	5,500	5,500
Yearly cost	$12,103	$11,789.25
Power cost per engine-hp. per year, not including steam used for nonpower purposes	$65.42	$58.95

These estimates do not include any charges for depreciation and interest on money invested in the power plant.

Lastly the engineer may prepare a table of coal and power costs per unit of production of his plant. This will be a tabulation that will interest his employer, and is the only fair manner in which to judge the economy of power production.

Conclusions and Recommendations

A general review of the work of the year should be incorporated in the annual report. It need not be elaborate; merely a statement of facts that stand out clearly as important. After the general description of the plant, work that has been done on it, and all important information have been given, the engineer may proceed to give his recommendations for the future welfare of the plant.

It is a written plea from the man in charge to his superior, in which he asks that he be allowed to make certain changes or purchases. He may thus demonstrate by his report that such and such a line of action is advantageous, and he may show in this manner that he is a capable, wide-awake engineer.

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Professor Huxley, the celebrated scientist, could not be accused of undervaluing science, but he never lost sight of the fact that practical work kept the world moving. In addressing the students of a scientific school he once took occasion to urge the necessity for combining skill in handicraft with technical knowledge. All his life he had been trying to persuade people that, if they wanted to teach physical science, it was no use to proceed by filling the minds of the students with general propositions which they did not understand, from which they were to deduce details which they comprehended still less. The learned professor spoke of the advances made in providing scientific education for artisans and anticipated that progress in this line was destined to become very rapid, all of which has been verified.—"Railway & Locomotive Engineering."

The Kingsbury Thrust Bearing

The design of the Kingsbury thrust bearing consists in general of a collar rotating with the shaft and sliding on stationary parts arranged to receive the thrust, the whole being flooded with oil. The bearing somewhat resembles the ordinary collar-thrust bearing used on line shafting, etc., but it differs from the common type in one essential feature, as described below:

In the ordinary collar bearing the stationary bearing surface is provided by a continuous ring, while in the Kingsbury bearing this ring is divided into several independent sectors or "shoes," generally six in number. These shoes are shown at *A* in the photograph.

Each shoe is so supported against the thrust that it may independently align itself to the different conditions of bearing surface. This self-adjusting feature is provided by rounding the supporting surface or seat of the shoe, so that it may rock or pivot over its central area. The seat of the "shoe" is shown at *B* in Fig. 1 and at *C* in Fig. 2.

The bearing here shown is such as is used in the 10,000-kw. vertical generating units, load 410,000 lb., speed 94 r.p.m., at the McCalls Ferry plant of the Pennsylvania

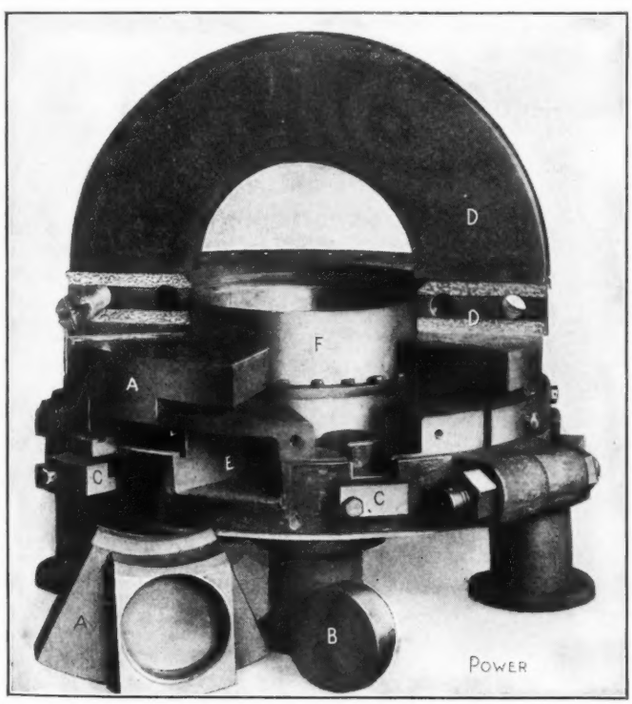


FIG. 1. KINGSBURY THRUST BEARING PARTLY DISASSEMBLED

Water & Power Co., and referred to in this issue on page 658 of the article describing that plant. Tests were made of the bearing at this plant and the following data obtained:

Outside diameter of collar, inches	48
Total load on bearing, pounds	410,000
Area of shoes, square inches	1,160
Unit pressure per sq.in., lb.	350
Revolutions per minute	94
Mean surface speed, ft. per min.	900
Oil flow through bearing per min. gal.	15
Kind of oil	light mineral
Mean temperature rise of oil in bearing, deg. F.	4.5
Frictional loss in bearing, hp.	9
Coefficient of friction	0.0008

For large bearings, such as the above, each shoe is provided with adjusting wedges *C*, Fig. 1; *D*, Fig. 2, for equalizing the load on the "shoes." The runner *D*, Fig. 1, revolves with the shaft and on an oil film between the runner and the "shoes." In Fig. 1, *E* is an oil-inlet passage and *F* is the inside oil-retaining ring. Half of the runner is here shown in section, the other half being stood on ends to show the construction.

The shaft collar, Fig. 2, is generally made of cast iron or mild steel, the shoes of cast iron or cast steel and faced with babbitt metal. For very heavy loads at slow

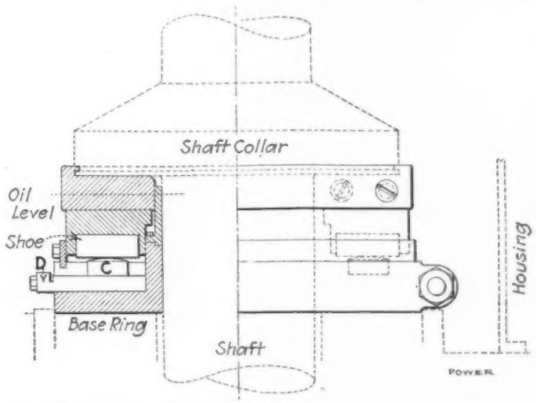


FIG. 2. PARTIAL SECTIONAL ELEVATION OF KINGSBURY THRUST BEARING

speeds a harder material than babbitt is used, such as chilled cast iron or hardened steel with brass or bronze shoes. The bearing is made in halves when required to allow of assembling it without desturbing the shaft collar.

As applied to steam turbines, this bearing ordinarily carries 500 lb. per sq.in. as a maximum, the linear speeds being 3000 to 4500 ft. per min. For vertical waterwheels and similar work the pressure is from 250 to 400 lb. per sq.in., the coefficient of friction lying between 0.001 and 0.002.

Tests have shown that this bearing practically has no limit as to speed so long as there is a good circulation of oil. Tests for overload capacity have been made on a bearing running at 3600 r.p.m., 4500 ft. per min., on which the load was gradually increased from 800 to 10,000 lb. per sq.in. without causing failure of the oil film. At 10,000 lb. the pressure was sufficient to crush the babbitt metal, causing it to flow laterally in all directions.

The bearing was invented by Albert Kingsbury, of Pittsburgh, Penn.

Dundee Falls Development

At Dundee Falls, Maine, on the Presumpscot River, a new power station for the S. D. Warren Co., paper manufacturers, is being erected under the general supervision of the Stone & Webster Engineering Corp. The dam structure, about 1400 ft. long, is of earth, with the power house and spillway of reinforced concrete nearly in the center. The head is to be 50 ft., with a wheel capacity of 4500 hp. The concrete spillway is of the gravity-suction type.

Power will be supplied by three 33-in. horizontal turbines of the wicket-gate type, each capable of developing 1500 hp. at 277 r.p.m. Each wheel is direct connected to an 800-kw. generator operating three-phase at 60 cycles per second, and at a pressure of 11,000 volts. In each case the exciter is on an extension of the generator shaft.

ELECTRICAL DEPARTMENT

Electric Elevator Questions and Answers

By A. C. Waldron

Name some causes for magnetic-control elevators not starting.

The car may be down so low that the counterweights have come against the limit switches at the top of the well, which breaks the circuit and throws out the circuit-breaker. Most electric elevators are supplied with two spanner wrenches which fit round the brake-wheel hub, and by slightly relieving the tension on the brake band, the motor can be turned. This will raise the car and lower the counterweights away from the limit switch. If there are two sets of counterweights and the brake tension is completely relieved, the elevator will race to the roof, sometimes unaided.

Another way is to put a screwdriver in the limit switch while it is open; this will close the circuit and the car can be moved.

Another cause for the car not starting may be the ropes riding over each other on the lifting drum, this extra thickness of rope bearing against the "slack cable" device, underneath the drum, and tipping it, which breaks the circuit and cuts off current to the motor. The remedy is to use the spanner wrenches, as before, to wind the rope until it is running right.

If the electrical contacts are not kept clean and bright the car will not always start. If the car is above the top floor about two feet it it will come against the limit switch and cut off all current. In this case it is easier to use spanner wrenches to slacken the brake band and bring the car down enough to allow the limit switch to close.

Blowing of fuses will, of course, stop the car and throw out the circuit-breaker.

What will cause a car to run past floors?

If there is a short-circuit in the controller it will arc from one contact to another, and cause the brake to hold up.

Remedy: Remove the burnt nonarcing baffle-plate and replace it with a new one. Also if the tension on the brake spring is slack or the brake band is hot it will cause the car to slide. Having put too much soap on the brake pulley will cause the car to slide by floors.

What causes a solid stop on the up trip?

If the top brake band is too tight it will jounce the car. The remedy is to take out the bolt in the brake band and give the screw-eye half a turn less. If a solid stop occurs on the down trip, take out the bolt on the bottom brake band and slacken up a half turn. Never take out both bolts at once unless a timber is put in the main-rope drum wheel, because the car will run away to the roof.

What care should be given electric elevators in general?

Watch the ropes for stretching, especially the car counterweight ropes. Do not allow the weights to bang on the basement floor as they are cast iron and are liable to brake. They should be taken up in six or eight months, depending on the quality of rope used.

How should a rope be inspected?

When the rope passes over the sheaves at the top of the elevator well, have the operator run the car two feet at a time, and broken wires can be plainly seen and examined.

How many broken wires are considered dangerous?

The writer has seen as many as 15 broken wires in a length of 2 ft., this instance being in one of the busiest and largest office buildings in Boston. Ropes are frequently kept running a long time with many broken wires if they do not occur in a short distance from each other.

Where should one look for the greatest number of breaks in a rope?

In the back drum counterweight ropes, because this frequently has twice as many sheaves to run over, making twice as much bending. Attention should also be paid to the worm gear, which is extended from the motor shaft, and the gear casing should be kept half full of oil, preferably castor oil. The automatic feeding grease cups on the traveling sheave over the main drum should be kept full. If they are not, the sheave will refuse to travel and will ride the ropes over one another, in which case they are liable to run off the sheave.

How may a loaded car be started after the safety devices have set?

The first thing to do is to get the passengers out. If this is impossible, assure them that all will be well if they remain quiet. Then see if the lifting ropes are slack. If they are, take the spanner wrenches and turn the motor or brake shaft enough to tighten the lifting rope so as to hold the car and its load. Then get into the car and take up the small, round, floor plate and with a socket wrench, unscrew the safety very easily. If the safety is slackened sufficiently, the elevator will hang normally on the lifting rope. Next, go to the top of the elevator well and throw back the safety lever, which will throw out the safety-governor clutch so that the car can be run. In case the stoppage is between floors, take the spanner wrenches and lower the car to the nearest floor to let off the load, after which put the safety rope back in the ball clutch on the top of the car; then operate the car from the switchboard controller for several trips to see that everything is in good order before anyone gets into the car.

What care should be given the safeties?

Every month raise the car above the basement floor, get under it and pull the rope that is wound up on the safety-clutch shaft. This will set the safeties, and keep them in good working order. Then get into the car, take up the round floor plate and with a socket wrench as previously mentioned slacken up on them until they do not drag.

What care should be given the guide rails?

Both the car rails and the counterweight rails should be scraped and oiled once a week to keep the car shoes from

rubbing hard on the guides. An excellent lubricant consists of one quart of cylinder oil and half a pint of flaked graphite, in warm weather, while in cold weather, there may be added red engine oil to give the proper consistancy. If the babbitt in the car shoes is badly worn and causes grating, a graphite candle, held on each side of the rail for a few trips, will stop grating; or, the shoes may be slackened so that they will not jam against the rails. Jamming is bad, both on the car rails and on the counterweight rails, because it wears them to a sharp burr edge, necessitating treatment with a file.

Care should be taken in using the proper lubricant on the overhead sheeves, because a grease that will do in winter will not always give satisfaction in the summer, and *vice versa*. Many a passenger has got a new suit or a dress soiled because of a drop of lubricant from the bearings of the overhead sheeves. Let the attendent keep the drip pans empty and this will not happen.

Why are two sets of counterweights used on an electric passenger elevator?

One set is to nearly balance the car. This set usually is above the other. The bottom or back-drum counterweights are fastened by cable around the rope-drum wheels and weighted to counterbalance the average passenger load. This lessens the load on the motor when the car is carrying normal load; hence when the car is lightly loaded, it takes more current (on the return trip) than when a fair load is carried, because when a fair load is carried, if the back-drum counterweights are of the proper weight, the motor simply slides along. With no load the car tends to run away to the roof if the brake is lifted, or becomes disabled.

Alternating-Current Conductors

By Clifford R. Parliman

The tendency of alternating current, when transmitted along a conductor, is to travel in concentric circles. Take, for an example, the cross-section of a round, solid-copper conductor, Fig. 1, as a graphical explanation of current travel. We are given to understand by Steinmetz and other investigators that the current density at the center of such a conductor is at a minimum and gradually increases toward the periphery. Its density, therefore, attains a maximum value at the periphery; causing what is technically known as a "skin effect."* The result, however, of overloading a conductor is leakage, as presented at *A*, Fig. 2; this is proportional to the overload. The current density, nevertheless, would still be greater at the periphery.

Assuming that this theory of alternating-current transmission is correct, then surely there is an unnecessary waste of material at the core, when the proportionate carrying capacity of a cross-section is considered.

Another bad feature of such a conductor is that as the circumfluent current density becomes a maximum at the periphery, the conductor is susceptible to overheating. Both of these faults, however, can be obviated by a hollow conductor, as in Fig. 3, where the proportion of orifice diameter *C* to the thickness of walls *T* is as 2 : 1. It is evident that with a larger exposed surface (*F* and *F'*) the cooling conditions of this hollow conductor will be greatly improved over that of the solid one, also the current density would be more evenly distributed over the cross-section.

It might be mentioned that the New York Edison Co. is planning to experiment upon the use of hollow busbars in one of its large stations.

Fig. 1

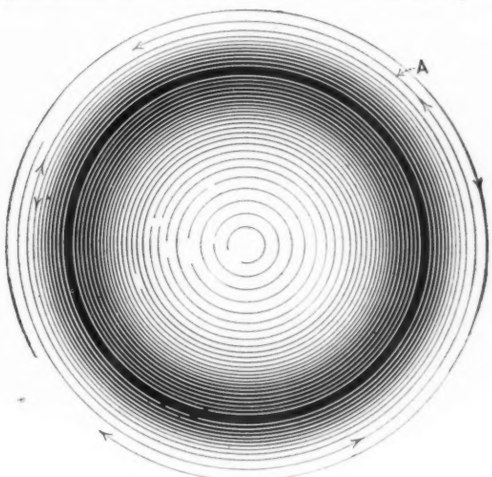


Fig. 2

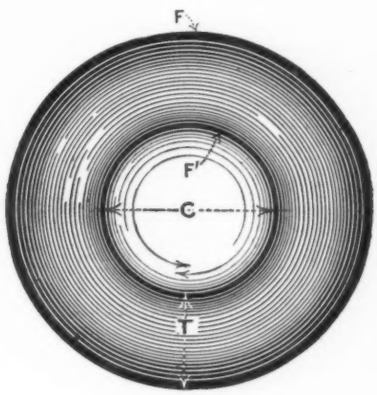


Fig. 3

*Skin Effect—see Foster's Hand Book.

Quick Restoration of Service

During the last week in March, Columbus, Ohio, was inundated by the Scioto River and for over two days the main generating units of the Municipal Lighting plant were under water. After the water went down the generators were dried out by running them with the armatures short-circuited, in the usual manner. On Saturday afternoon, however, Apr. 12, a shirt-circuit developed in the leads to two of the turbo-generators, one a 1000-kw. and the other a 2000-kw. machine. These dead shorts followed the leads into the high-tension stator windings, which were so badly damaged that the two machines will have to be rewound. The branch office of the Allis-Chalmers Co. in Cleveland received notification of the accident on Monday afternoon and the information was immediately wired to the factory in Milwaukee. The generator end of a 1000-kw. unit was in stock. This was loaded and shipped from the factory on Tuesday, and by Thursday evening it had been connected up and was able to carry a part of the load on the station.

GAS POWER DEPARTMENT

Dust Determinations for Blast-Furnace Gas

By Everard Brown

There are several methods employed for measuring the amount of flue dust in blast-furnace gas. Where such gas is used for gas engines, knowledge of its dust content is essential, because it permits of careful surveillance of the gas-cleaning plant and its efficiency. That all blast-furnace gas must undergo a thorough cleaning before it is introduced into the engine is, of course, understood.

In making determinations of this kind the method of taking the samples is of prime importance. In the first place, the samples should be taken from the gas main at a point between the last or final cleaning apparatus (several stages of cleaning being necessary to make the gas suitable for use in internal-combustion engines) and the engine, at least 12 or 15 ft. from any bend or constriction, in order that the current of gas may be free from local disturbances.

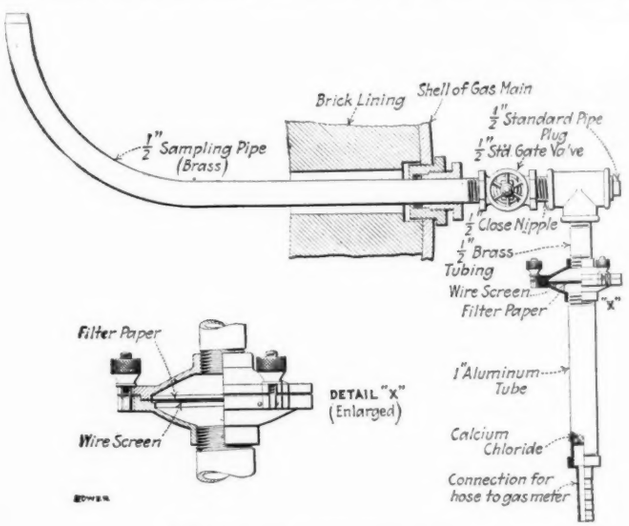
The sampling pipe should be of hard-drawn brass, which, because of its polished internal surface, affords the least opportunity for dust accumulation. A half-inch tube is sufficiently large for the purpose, bent to any convenient radius but not less than 6 in., so that it can be inserted in the main with its entering end pointing against the current of gas. It is important, however, that the bent portion within the main be parallel to the sides of the latter so as not to change the direction of flow nor impede the progress of the gas. Moreover, it is advisable to reduce the walls of the brass tube at the entering end to a sharp edge so there will be as little disturbance of the gas as possible at this point. Wherever possible the sampling pipe should be inserted on the horizontal diameter of the gas main and should extend into the stream of gas from one-fourth to one-third of the internal diameter of the main, in order to secure a representative sample. There appears to be some difference of opinion on this point, however, the contention being that with a fairly clean gas it is not necessary to extend the pipe further than a few inches beyond the lining of the gas main. The necessity for bending the sampling pipe so that its entering end will face the current is also doubted by some; nevertheless, it can do no harm and might possibly do some good. With gas that was not thoroughly cleaned, for instance, it would be rather difficult, even with artificial suction, to overcome the inertia of the heavier dust particles and cause them to change their direction and enter a pipe that sticks straight into the gas main, whereas with a curved sampling pipe this would not be necessary.

In taking any gas sample for the purpose of determining the amount of its suspended matter, it is desirable to maintain, as nearly as possible, a velocity in the sampling pipe equal to that in the gas main itself. This is rather difficult, however, because there is sure to be some retardation within the former. Various devices, such as siphons and other inductive agents, have been tried to increase the velocity in the sampling pipe, but as far as the writer knows the success of these has been doubtful.

Probably the most common method employed in making flue-dust determinations consists in filtering the blast-furnace gas through a tube packed with absorbent cotton. This method is rather crude, however, and is subject to many chances for error. In fact, the simplicity of the apparatus involved is about all that commends it.

In the first place, this method is hardly practical for checking up the efficiency of operation of a gas-cleaning plant because of the long period required for each individual observation and also because of the great amount of time taken up in drying and weighing the cotton. This means that probably not more than one determination can be made each day.

With the use of absorbent cotton as a filtering medium it is necessary to first thoroughly dry it over phosphorus pentoxide or calcium chloride, after which it must be carefully weighed and packed in its glass container. Then,



Details of Sampling Tube

when a certain quantity of gas has passed through, this cotton must be again thoroughly dried and weighed, the difference in weight determining the amount of dust and impurities contained in the sample of gas passed through. This process not only requires considerable time, but also skill and attention, because of the highly hygroscopic character of the filtering material. Furthermore, in packing the cotton into the glass tube, there is another source of error on account of the practical impossibility of two operators to so pack the cotton as to get the same homogeneity of filter, without crevices and channels through which particles of the gas might pass unfiltered. This also holds true of one operator preparing a number of filters.

Another method of making flue-dust determinations consists in first passing the gas through several U-tubes filled with glass pearls for condensing the moisture and then through glass-wool as a filtering medium. This

method has an advantage over the previous one in that glass-wool is not so highly hygroscopic as absorbent cotton. Perhaps another advantage is the ability to weigh the glass tubes, including their filling, on a chemical balance. The disadvantage of the method is the care necessary in handling this bulky apparatus.

Twelve or fifteen years ago an entirely different method of determining the amount of suspended matter in blast-furnace gas was brought out by Leo Martins, of Germany, whereby ordinary Swedish filter paper is used as a filtering medium. The accompanying sketch shows the apparatus in slightly modified form, which seems to be an improvement over the original construction.

The filter paper, which is about 5 in. in diameter, is contained in a conical-shaped, metallic receptacle made in two parts to permit of the ready insertion and removal of the paper. The halves of this container are held together by three swing bolts fitted with thumb nuts so that little time is required to get at the interior. The paper itself is supported by a wire screen to prevent tearing, due to the pressure of the gas. The upper part of the apparatus is connected to the gas main and the lower to a wet-gas meter measuring the volume of the gas sample taken. In order to catch the moisture due to condensation of steam and vapors in the gas, a tube containing calcium chloride is attached to the lower part of the device, through which the sample must pass before it is metered. The reason for this is obvious, as it is not desired to take into account any moisture that might be contained in the gas. Furthermore, the whole apparatus is inclosed in a box, usually of wood, with an asbestos board lining, within which a sufficiently high temperature is maintained by means of an electric incandescent light or other device, to prevent condensation and accumulation of moisture on the filter paper.

The container for the filtering paper should be of polished brass so as to present as little adhering surface as possible for the gas. This will practically eliminate any error, due to precipitation of dust on the interior walls of the apparatus. For the same reason the inlet pipe should also be of brass. The tube containing the calcium chloride is usually made of aluminum and the rest of the connections of ordinary standard material. A hose should be used, however, to connect the lower end of the calcium-chloride tube with the gas meter so that there will be enough flexibility to allow the filter container to come apart by simply loosening the three thumb nuts and pulling down the bolts. The operation is as follows:

Before inserting the filter paper, it is thoroughly dried and carefully weighed. A sufficiently large sample of gas is then drawn through the instrument to assure an appreciable amount of dust on the filter paper, this quantity of gas being recorded by the wet-gas meter. All the dust and impurities contained in this sample are deposited on one side of the paper, which is then removed, dried and weighed again, the difference between the two weights being the weight of the impurities extracted and in turn the weight of the impurities per cubic foot of gas.

If the moisture content of the gas is also desired, which is most generally the case, the calcium chloride in the attached tube can be weighed before and after the sample is taken and the difference in weight will be the amount of moisture absorbed. If the gas contains a large amount of moisture, two of these tubes may be used.

This method of making dust determinations is probably the most satisfactory of all methods in use at present, as it has the advantage of being reliable and practically independent of the skill and ability of the operator. It also enables the chemist to make a number of determinations per day and if two instruments are used almost continuous records may be had.

It must be understood, of course, that the method described, or any other method for that matter, will not give as satisfactory results with raw gas that has received no cleaning as with gas sufficiently cleansed for use in a gas engine. This fact, however, does not necessarily reflect on the method itself because it is rather doubtful whether any apparatus could be devised that would take care of the very large quantities of flue dust in uncleaned blast-furnace gas.

Junkers vs. Diesel Engine*

Though not a Diesel engine adherent to the extent of failing to see certain fundamental advantages in the construction of the Junkers engine, I do not believe that some of the statements made by Mr. Junge in his discussion of this engine, will bear close scrutiny. First, the attempted comparison between the two engine types is entirely too broad for bringing any light whatever on the subject, and, second, the claims made with respect to the superiority of the Junkers engine are too broad.

Mr. Junge enumerates certain features relating to the combustion space and to the scavenging, which are regarded as necessary for obtaining the highest efficiency, and which unquestioningly are correct in principle; then he shows that the Junkers engine possesses these favorable features; and from that he concludes, without showing that the Diesel engine cannot equally well possess these features, that the Junkers engine must be the more efficient. The main proposition on which this higher efficiency of the Junkers engine is based Mr. Junge expresses thus: "For obtaining high efficiency it is necessary to keep the ratio of area to volume of the combustion space as small as possible. Of course, this is not to be taken literally. The least possible ratio of area to volume is possessed by a sphere, but the combustion space of the Junkers engine is not spherical. A cylinder possessing the least possible ratio of area to volume is one of a height equal to its diameter. If taken literally Mr. Junge's proposition would, therefore, mean that for obtaining the highest efficiency in an engine using a compression pressure of approximately 500 lb. it would be necessary to employ a piston stroke something like twelve times the cylinder diameter. The fact to which Mr. Junge's statement alludes can be stated briefly only by saying that when the compression is high the stroke of the engine should be somewhat long. The area of the surface confining the combustion space should, of course, be a minimum. It would not be impossible to design a Diesel engine of the type in question which would fulfill these conditions practically as well as they are filled in the Junkers engine.

Another proposition on which the claims for a higher efficiency of the Junkers engine seem to be based is that, because of the shorter crank radius of this engine, a higher piston speed can be used. This would be correct if all other conditions were the same, but not when comparing two engines of entirely different construction; it

*Discussion of a series of eight articles on the Junkers engine by F. E. Junge, which were concluded in the Mar. 25 issue.

all depends on the weights of the reciprocating masses. In the Junkers engine there are attached to the rear piston a piston rod, a heavy yoke, and side rods, with which the Diesel engine is not hampered. The question will then be: How much greater weight of the reciprocating parts may be allowed the Junkers engine, for equal smooth running at the same aggregate piston speed as that of the Diesel engine?

For smooth running (without backlash in the crankpin boxes) it will be required that the accelerating force on the crankpin shall not exceed a proper limit. Under normal conditions, as to the length of the connecting-rod, this force is

$$\frac{P}{F} = 0.000034 \frac{G}{F} N^2 r$$

where $\frac{P}{F}$ equals maximum accelerating force per square inch of piston area at the head end; F represents the area of the piston; $\frac{G}{F}$ the weight of the reciprocating parts per square inch of piston area; N the revolutions per minute, and r the crank radius in inches.

In the accompanying sketch the force $\frac{P}{F}$ is the distance AM and the line AB is the acceleration curve for the reciprocating masses. The line DEF is the adiabatic compression line for a compression to 500 lb. gage, and the dotted line GHB represents the resulting pressure between the bottom connecting-rod box and the crankpin, per square inch of piston area. If the numerical value of the negative accelerating force at I becomes so great as to carry the dotted line below the base line MN, it would indicate that backlash in the crankpin box will occur at that point.

To avoid this $\frac{P}{F}$ must not be more than, approximately, 0.4 of the compression pressure C, for a pressure approximating 500 lb. Hence,

$$0.000034 \frac{G}{F} N^2 r < 0.4\, C$$

$$\text{Substituting } N^2 = 9 \frac{S^2}{r^2}$$

where S = Piston speed in feet per minute;

$$\text{whence } S < K \sqrt{\frac{Cr}{\frac{G}{F}}}^{*} \qquad (1)$$

K being a constant which varies with the compression.

Wishing to compare the limiting piston speed of the Junkers engine with that of the Diesel engine of the same diameter and stroke, we write

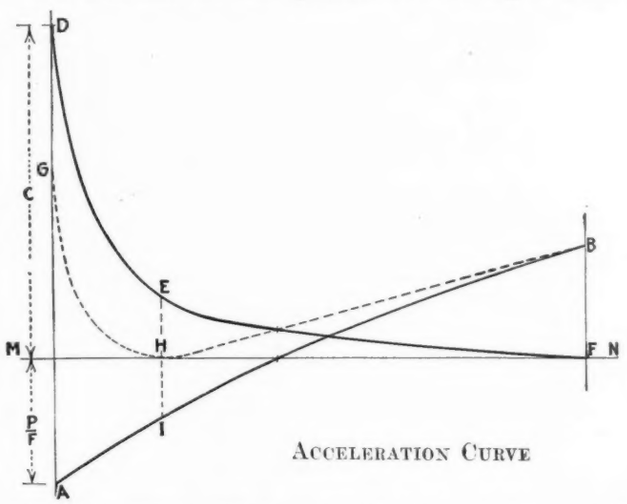
$$\frac{S_J}{S_D} = \frac{2\sqrt{\frac{Cr}{\frac{G_J}{F}}}}{\sqrt{\frac{2\,Cr}{\frac{G_D}{F}}}} = \frac{\frac{2}{G_J}}{\frac{1.41}{G_D}} \qquad (2)$$

S_J is the aggregate piston speed of the Junkers engine; S_D the piston speed of the Diesel engine; G_J and G_D the respective weights of the reciprocating parts.

For equal weights of the reciprocating parts the Junkers engine has, thus, with respect to the allowable piston speed, an advantage over the Diesel engine in the ratio of 2 to 1.41. This advantage may be lost, however, if its reciprocating parts are heavier than those of the Diesel engine; and equation (2) makes it evident that it is futile to discuss the question of allowable piston speed of the two types without considering the weights of their reciprocating parts.

That the scavenging of the Junkers engine must necessarily be more efficient than that of the Diesel engine because of any differences in the manner in which the air is admitted to the cylinder, cannot be taken for granted. It must be conceded, though, that an uncooled inlet valve of the Diesel engine may have some effect on the temperature charge, without greatly affecting the efficiency.

It is true that the rear cylinder-head casting of a single-acting engine appears complicated and has proved susceptible to breakage, but as far as the complication of the casting is concerned, it does not seem to cause any alarm in the uptodate foundry, and if properly designed it should not be more liable to break than any other part.



Acceleration Curve

Viewing the whole question in a broader sense the efficiencies of the two engines may be considered practically the same, there being no good reason for doing otherwise, until conclusive tests have proved such an assumption false. Then, disregard minor details, and we shall find that the essential features are as follows:

In the Junkers engine there are two sets of reciprocating working elements which practically balance each other, and there are no longitudinal strains in its frame, cylinder or cylinder connections; and this latter feature should not be considered lightly. In the Diesel engine the reciprocating elements are the simplest, but they are not entirely balanced, and there are heavy longitudinal strains in the framework that must be taken care of. The Diesel engine will, therefore, require a heavier foundation and a much heavier frame, cylinder-jacket walls and cylinder connections, than the Junkers engine. The Diesel engine may be said to have some advantage in that it can be installed more compactly as a two- or four-cylinder cross-connected engine. But as for weight there is no doubt but that the Junkers has the advantage.

A. M. Levin.

Chicago, Ill.

*Equation (1) may be written $S < K_1 \frac{C}{\frac{G}{F}^N}$. For a compression pressure of 500 lb. K becomes approximately 3800 and for 100 lb., 7300. See the "Modern Gas Engine and the Gas Producer," by A. M. Levin.

HEATING AND VENTILATION

Some Notes on Ventilation

An interesting paper on ventilation was read recently by Arthur K. Ohmes before the Institute of Operating Engineers, of New York City. He told how difficult it is becoming to secure a supply of fresh air in large cities where the atmosphere is laden with oil and gasoline from automobiles and objectionable gas and cinders from the stacks of large heating and power plants. On dry, windy days, dust and dirt from building operations and from the streets add to the difficulty. The effect upon ventilation from contamination of the air by the human breath was discussed to considerable length, inorganic contamination, such as dust or gas in the air, was given passing mention and the heat given out by different kinds of lights was tabulated.

Air Quantities and Cubic Contents

In a school room used for a few hours in succession it is usual to allow 1800 cu.ft. of air per hour per pupil; for theaters used only once a day for a few hours, 1000 to 1500 cu.ft. per hour per occupant; for hospitals, 3000 to 4000 cu.ft. per hour per bed. Large banking rooms may have about three changes of air per hour; engine and boiler rooms, according to the machinery layouts, 10 to 40 changes of exhaust per hour and 8 to 25 changes of air supply per hour. These values must be used with discretion because special conditions may require a greater amount of air.

To obtain the amount of air advocated above there are in general two ways: the natural and the artificial. The only natural means that need be considered are the windows and it is but right to point out that perhaps 90 per cent. of all buildings are ventilated in this way. Drafts and uneven temperatures are the chief objections to natural ventilation and besides the possibility of securing an ample amount of air through windows has its limitations, depending, of course, on the cubic contents available per occupant and the number of windows. The cubic contents available for each person in a room is generally called the "air cube" and a fair average in different buildings is as follows:

Hospital wards (modern)	2000 cu.ft. per bed
School (by law)	200 to 210 cu.ft. per pupil
Sleeping rooms (ordinarily in suburbs)	500 cu.ft. per occupant
Liberal offices	500 cu.ft. per occupant
Crowded offices	250 cu.ft. per occupant
Theaters	200 to 400 cu.ft. per person
Ordinary railroad car	60 to 70 cu.ft. per person
Electric car (with strap hangers)	25 to 30 cu.ft. per person

With a skillful arrangement of windows and heating surfaces, with people allowed to move away with perfect freedom to places where an open window does not annoy them and with an air cube of 500 cu.ft., fair results with window ventilation may be secured, provided none of the objections general to window ventilation exist around the building. To secure a constant supply of air by manipulating the windows is almost impossible. There is generally too much, or too little air, and the economy in fuel usually attributed to this method of ventilation is but seldom secured.

Dust Troubles

The shortcomings of window ventilation for many kinds of buildings has been the cause of installing artificial ventilating plants which furnish a constant supply of tempered air irrespective of wind and weather conditions. The quality of air secured by artificial ventilation is at the present time a much discussed subject. If only exhaust ventilation is provided, the air then enters ordinarily through the windows to be heated, in the colder weather, to room temperature by the radiators. If air is supplied by a blower, it is heated to nearly room temperature by a tempering coil. There are people who seem to think that air heated by a tempering coil is impaired for breathing, evidently basing their judgment upon the dryness of the air and the burning of dust on radiators and pipes. The drying effect of heat cannot be avoided unless the air is moistened. As to the burning of dust on heated surfaces, it should be realized that different kinds of dust require higher or lower temperatures before burning can take place. The approximate temperature at which the ordinary dust begins to burn is 160 deg. F. Thus a steam radiator, whose temperature is generally about 212 deg. F., will be capable of burning this dust, whereas a hot-water radiator, at, say, 140 deg. F., would not affect the dust at all.

After heat has been turned on, scarcely any dust will settle on the hot radiators, because of the rising air current carrying away the heat. Almost any steam-heating plant will smell at the beginning of the season, particularly if the radiators have not been cleaned during the summer, but if steam radiators are wiped off every day with a wet cloth no offensive odors from burning dust will be present.

Three Ways to Create a Flow of Air

In a ventilating system there are three ways of creating a flow of air. The flow may be due to wind velocity as utilized in vent and smoke-flue caps, generally called ventilators; to temperature difference, as in vent flues, or to mechanical means, such as blowers and fans. With ventilators the amount of air handled depends mainly upon wind velocity, and with increasing wind, where naturally more air is coming into the building, due to the many window leaks, and when the least amount of artificial ventilation is necessary, they will naturally handle the most air.

In many buildings the need of ventilation is greatest in the summer months, and at this time the vent flues will handle the least amount of air, because this depends on the temperature differences between inside and outside. The only positive means of supplying the air is by means of a blower or fan, for with either the amount of air handled does not depend upon the velocity of the wind or temperature conditions primarily.

The features of an artificial ventilating system to which most consideration must be given are the air inlet, the tempering coil, the duct system, and the cleaning

devices. The fresh-air inlet must be located at a point where such air really exists. This may be at the ground level or on the roof, or perhaps at a certain height between. Common sense in each case will dictate the best location. The opening must be protected against rain by louvers or hoods, and with a screen to keep out birds and débris of various kinds.

In the arrangement of the duct system, every precaution should be taken to guard against contamination. The practice of installing all kinds of pipes, even sewer pipes, in fresh air ducts, must be condemned. Many ventilating plants have proved a failure from this very reason.

The tempering coils must be designed and operated so as to secure an even temperature of air. Air filters and air washers for cleaning the air must be designated as necessary evils, for it would certainly be desirable if equally clean air could be secured without their installation. Generally speaking, washers have the advantage of cleaning the air more thoroughly than filters. On the other hand, air washers are costly to install and operate, and when they are not in operation the air is not automatically cleaned as with a filter.

Operation of Ventilating System

Temperature changes within a room with a ventilating apparatus must be effected carefully. The room, the hall, the theater or the schoolroom should be prepared for the best atmospheric and temperature conditions before the people assemble. It is almost invariably better to err on too low a temperature than too high, because it takes but a few moments to heat up a room, without any of the occupants knowing anything about it, whereas it is more difficult to cool a room, even a degree or two, without making it evident.

Air filters must be kept clean and all the sprays in continuous operation. The water should be renewed often, and the dust exhausted from the air removed, as otherwise objectionable odors will soon develop. The temperature of the primary coils for an air washer is better set low if the apparatus serves offices, schools, theaters, etc., as otherwise too much moisture will be added to the air. The dust systems must be kept clean, and all moving parts of the fan as well. The tempering coil should be cleaned at least once a year.

For the proper operation of ventilating apparatus the engineer requires a few instruments, such as accurate thermometers, a hygrometer, and an anemometer. The ordinary dry- and wet-bulb hygrometer or the sling hygrometer is sufficiently accurate, and, if properly handled, the anemometer will give approximate results. Another instrument which may occasionally become of value to the chief engineer is the ordinary U-tube draft gage for determining the working pressures of the apparatus. Care must be exercised to distinguish between the velocity, static and dynamic pressures.

In Europe, particularly in Germany, the operation of ventilating apparatus is quite different from here. In this country we are accustomed to rely as much as possible upon the automatic regulation of temperatures, air supply, etc.; in Germany the operation is mainly done by hand. In large plants will be frequently found complicated boards, not unlike switchboards, upon which are mounted numerous instruments, such as electric long-distance thermometers and micromanometers, gages, operating devices for large dampers, etc., all for the purpose of enabling the engineer to control the entire ventilating apparatus and temperature conditions existing in the building from his switchboard in the cellar. He can determine the pressures and temperatures existing in three or four parts of the house, and is supposed to work his ventilating apparatus according to a certain tabulated formula.

No centralized service will ever be successful, unless the engineer has an intimate knowledge of the plant and its workings. Few operating engineers in this country would take the necessary pains to properly operate a centrally controlled plant. For the meantime the localized automatic control is therefore superior, although a combination of both systems may be the ultimate outcome.

CORRESPONDENCE

Check Valves Relieve Trouble

In one of the buildings to which the writer supplies heat, both the one-pipe and two-pipe systems are installed. Some of the radiators are connected to the one-pipe system and all of the coils are on the two-pipe system. The building has three stories and basement and is heated from a central power house, the supply and return pipes being in the basement. The one-pipe radiators are tied in with the returns of the coils on all three floors. A great deal of trouble was experienced in getting the cold air out of the coils before the steam would close the automatic air valves. Especially was this true in the six pipe coils heating two large rooms on the top floor. The coils would be warm at the supply end and return end, but the center and largest part of the surface would be stone cold. The supply main entered the building, which is about 80 ft. long, at one side of the basement near the end, being carried to the center and down to the other end. From each side risers were tapped for each floor, the top story being supplied from risers at the extreme ends of the supply main.

In operation, the steam to the one-pipe system, which, of course, had the pressure of the main supply, would back up into the returns from the coils, heating the air valves and closing them before the cold air was all out of the coils. Consequently, the coils remained cold.

By closing the return valves of the coils at night after they were drained, and then opening them in the morning after the coils were heated, the trouble was relieved. This, of course, necessitated some one walking to the top and all over the building twice a day. Finally, vertical check valves were put in on the return lines just above each supply pipe of the one-pipe system and there has been no further trouble. The steam pressure closes the check valve so the steam cannot reach the air valve by the way of the return, and the weight of the returns readily opens the check valve.

H. S. Sweetser.

Medford, Mass.

Mixing a handful of burnt lime with 120 grams of linseed oil, boiling down to the usual consistency of putty and allowing the plastic mass to spread out in a thin layer to dry in a place where it is not reached by the sun's rays, yields eventually a very hard putty. When required for use it is made plastic by holding over the funnel of a lamp; on cooling it regains its hardness.—"Penberthy Engineer."

EDITORIALS

Economy in the Boiler Room

The articles now appearing in the "Engineers' Study Course," dealing with combustion and analysis of coal, should be generally appreciated as one has only to step into the average boiler room to see evidences of the lack of knowledge on fuel economy. While making rapid strides in power-plant management and campaigning for more efficient engineers the boiler room has in a measure been left to take care of itself and in many cases labor entirely unfitted to the trust has been put in charge of the boilers.

A man may be a good fireman from the standpoint of safety, he may keep his surroundings clean and always have the steam up to the "top notch," but this does not always imply that he is getting the best results out of the fuel. Does he know the quality of the gas he is permitting to escape into the chimney? Has he any idea of the amount of excess air going into these gases, either through the fuel bed or the numerous cracks and crevices present in many boiler settings? Is he sure that the draft is the best for the fuel used and the thickness of the fuel bed? With the reliable instruments that are on the market at the present time it is within the power of every engineer to intelligently answer the above questions.

We do not mean to infer that the engineer or head fireman should be put to the expense of purchasing these instruments himself. It is our opinion that the majority of plant owners or managers are willing to purchase such devices if the engineer can show that he is familiar with the subject of combustion and fuel economy and can convince the management that by the constant use of such devices, a check can be kept on the average running conditions and money saved thereby. A talk on so much increase in the ratio of evaporation per pound of fuel may perhaps not be convincing or even interesting to the management; it must be told in dollars and cents. The possibility of saving five or ten per cent. in the fuel bills will always appeal.

Many may know that it is possible to make a ten per cent., or even greater, saving by keeping everlastingly at the combustion problem. We have in mind one boiler that consumed seven per cent. less fuel for the same capacity after stopping up the small cracks and crevices in the walls.

Too many boiler plants have not been provided with apparatus to properly measure the amount of water put into the boiler, the amount of fuel fed to the furnace and the pounds of steam the boiler is giving in return. No one would think of operating generators without ammeters to indicate the work that is being done. Trying to keep informed as to the load on the generator by feeling the heat given off would be considered ridiculous, but that is about as reasonable as the way many boilers are operated. They can go on day after day with overloads or they can "loaf on the job" and it is all taken as a matter of course.

It is more important to consider as an inseparable part of the boiler equipment such devices as will show the water evaporated, the coal burned, the steam given out and the furnace efficiency than to equip the prime movers with proper instruments. Economy here is all important, for the fuel lost in the boiler room can never be reclaimed.

Even if the boiler room is not equipped with the instruments and devices necessary to insure economy, it should not give the engineer or fireman license for inaction. He can become informed on the operation and necessities of such appliances, and be in a position to take charge of plants which include them in their equipment. The study of combustion and fuel economy is certainly worth all the time put into it and will bring big returns.

Learn How To Learn

Why is it that the practical man has so little use for the fresh college graduate? It is because in the eye of the practical man the college man knows nothing. What, then, did he gain by the time spent in school? Just this, he learned how to learn.

If this one lesson is learned by the practical man the college graduate has but slight advantage over him. The college man advances (provided he has push and ambition) because he knows how to teach himself what he ought to know and how to take advantage of knowledge thrust in his way. Thus equipped one has mastered the hardest part of any department of engineering.

Some readers have a habit of passing up phrases which they do not understand and then wonder why the rest of the article means nothing to them. Skipping phrases and words in this way is a harmful habit and induces mental laziness and discouragement.

One of the best ways to learn how to learn is to take each article, phrase and word and pick it apart as though it were an engine that has broken down and is being examined to locate the trouble. Those who read continually (when they have the time) find that understanding soon comes with less effort.

Some engineers and power-house men long ago decided that they have no brains for algebraic expressions, figures and the like. While they feel this way they will make no progress, but if they will only determine to apply themselves more, and make a business proposition of their studies, they will find it a kind of business that will pay good dividends in the future.

What Arbitration Can Do

That the wages of thirty-one thousand locomotive firemen can be increased three and a half to four million dollars a year without a strike which would have tied up fifty-four Eastern railroads, is a splendid testimony to arbitration as a means of settling capital and labor differences.

When this action of the firemen is contrasted with the stand taken by both sides in the majority of recent strikes,

it seems strange that the latter did not find some way to avoid paralyzing the big business interests and working great hardship to the workingman and seriously inconveniencing to the public.

It must be admitted that the patience and conservatism of the firemen were strong factors in the peaceful settlement of their contentions. Their vocation closely parallels that of the men in the stationary engineering field; both demand intelligence and skill and a knowledge that much depends upon their individual efforts. This is the main reason, we believe, why there have been few or no serious disagreements between power-plant employees and their employers.

Should the time come when it will be necessary to adjust questions of large moment in the operating engineering field, it is to be hoped that recourse will first be had to arbitration. While falling far short of being a panacea for all industrial difficulties, it furnishes the best means at hand for their peaceful settlement.

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Much-Needed Information

Two difficulties usually confront an editor when gathering material for an article descriptive of a power plant. These are getting cost data and accounts of operating troubles.

Just why the designing engineer should be reluctant to give out cost figures is hard to conceive. Surely there are no trade secrets to be thus divulged, and if there were, the data need not be of such a detailed nature as to reveal discounts, etc. What is most needed, is data upon various types of plants dealing with the total cost, cost of buildings, main units, auxiliaries and electrical equipment per horsepower or kilowatt of capacity. Most books on power-plant design are sadly deficient in this respect.

By giving out such information, consulting engineers would profit in the long run. In return for a comparatively small amount of information each individual would receive a large amount relative to a great variety of plants. This would be especially advantageous to the smaller firms whose business is not extensive enough to enable them to compile data of their own dealing with different types of plants.

Operating troubles generally do not reflect upon the apparatus itself. Sometimes they are due to wrong application of perfectly reliable equipment while more often they are the result of unforeseen circumstances or local conditions. In either event experience is the only remedy and engineers should gladly give their fellows the benefit of such experience. In this way many mistakes would be averted and much labor and expense saved.

Not long ago manufacturers were wont to carefully guard their shops from all visitors and even engine builders did not care to give out the performance of their products. Since the organization of several of the large engineering societies, however, with their custom of presenting and discussing technical papers, this condition has changed and much useful information is disseminated throughout engineering circles. It is hoped that this habit will be extended to include more discussions of costs and operating troubles, for, without question, both are subjects which are of interest, at least, to very many, and of intimate concern to not a few.

Discouragement of Ingratitude

What can requite the engineer who takes a plant without enjoying the confidence of his employers, is thwarted in nearly every improvement he wishes to make, and criticized no matter how well he does? We heard of such a case only a few days ago. In spite of no coöperation and in the face of all evidences that his employers are not satisfied with him, he has cut down their coal consumption from 24 to 10½ tons a day on an average. (One day recently he burned only 9¼ tons.) Where before the plant had to shut down at least once a week for some cause or other, he has had no shutdowns since he was there. In fact, without having the chance to do half the things to improve the plant that he would like to do, he is already saving the company four times his salary and yet he does not know what moment he may be discharged.

What is hard work compared to ingratitude? We can do to the very limit of our ability and gladly while it is appreciated, but nothing can chill our enthusiasm quicker or more thoroughly than failure to recognize our efforts. There remains only one comfort—the inner satisfaction of having done our best—a conscience that cannot criticize.

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The professional engineers are commencing to consider the advisability of legislation which will provide for their license or registration. A conference committee of the national engineering societies held a meeting during last month, to which were invited also representatives of the National Electric Light Association, the American Gas Institute and the Institute of Consulting Engineers, to consider the propriety of preparing a bill for registering engineers, which should be offered to the legislatures of New York and other states, should these bodies consider legislation in this matter essential. It was the sense of the conference that such a bill be prepared and this recommendation has been made to the councils of the organizations represented. The national engineering societies comprise the civil, mechanical, mining and electrical engineers. It will be but a step from the examination and registration of such men to the examination and licensing of operating engineers.

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A correspondent of *Engineering* (London) suggests that the pitting and corrosion which are of such frequent occurrence in condenser tubes subjected to the action of sea water, may be due to the internal stresses set up in the drawing of the tubes. He cites a number of cases of corrosion in copper pipes, and other situations which appear to be due to some such cause, and has been successful in preventing corrosion where it had been occurring by annealing the pipes before they were put into place.

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When a society only three years old can get out the crowd and the enthusiasm that was evidenced at the dinner of the American Institute of Boiler Inspectors (referred to on page 692) it is founded on right principles and made up of the right stuff. POWER is so heartily interested in decreasing accident and promoting safety in the handling of power-plant equipment that it is naturally in sympathy with the purposes of this society and wishes it continued and ever increasing success.

READERS WITH SOMETHING TO SAY

Why Belt Ran to One Side

Recently I erected a main-line shaft. Every care was taken to get the shaft in line and level, and when it was up I felt sure there would be no trouble encountered in starting. The next day I put on a 12-in. main-driving belt and started the engine, when, to my astonishment, the belt crawled over to one side of the pulley, about 4 in. of it sticking over the side. I was told that the shafting was out of line or out of level and it would be quite a job to change it, but I knew that was not the trouble for I had rechecked for line and levels after it was up. Another suggestion was that the belt was not laced to give even tension across it, and that the tight side was pulling away from the center, but as I had carefully squared the ends of the belt before lacing it and had drawn and laced the ends square with the aid of a belt clamp, I knew that could not be the cause of the trouble.

I again tested for levelness, thinking that possibly the sides of the building foundations might have settled unevenly, but found everything all right. I then tried the crown of the pulley on the main shaft to see if it was in the center of the pulley and found it all right. Next I started the engine to see if the pulleys ran true and found they did; they were also in line. For a few moments I could not imagine what else could be wrong. Finally I thought that possibly the pulley might be larger in diameter on one side than the other. After measuring both sides with a steel tape I found a difference in the measurements for both sides of the pulley of about one inch. Here, then, was the seat of the trouble.

The pulley had a wooden rim, solid cast-iron center, and to take it off the shaft would mean taking down the shaft, which would require at least a day's work. I set a temporary wooden rest in front of the pulley, took off the 12-in. belt and replaced it with a 3-in., which was positively guided to the small diameter end of the receiving pulley and then the large diameter end was turned down to equal the other end, using a common wood turner's chisel, the crown was also reduced a little as this change had increased the amount of crowning. The pulley was smoothed and the 12-in. belt put back. This time it ran true in the center and has never shown the least tendency to crawl to one side.

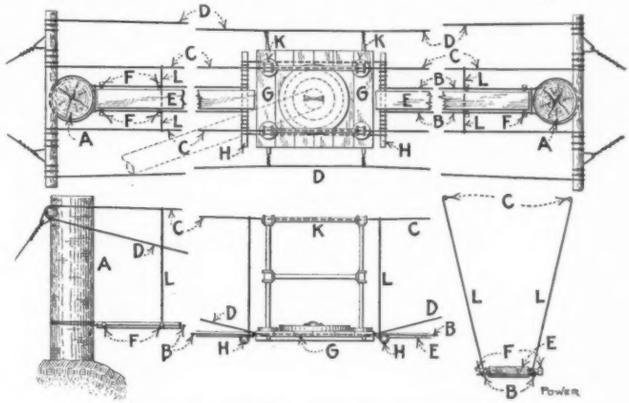
GEORGE P. PEARCE.

Exeter, N. H.

Miniature Suspension Bridge

At a certain New England plant, it became necessary to extend the injection pipe of the condenser 30 ft. into the river, where soundings revealed deeper and cooler water. There was danger that the foot valve, which was in the channel, would frequently become choked with fish and floating débris. Constructing a box for the protection of the valve was not difficult, but to design a passageway and platform over the water, that the screen might be daily cleared, demanded ingenuity.

The illustration shows the construction of a suspension bridge, which solved the problem. As shown, *AA* are two posts about 90 ft. apart, mounted one on each side of the river in line with the mouth of the injection valve. Connecting them are ½-in. woven wire ropes *BB, CC* and *DD*. The wires *BB* lead from near the base of the poles, and, through lag screws *FF*, support the 10-in. planks *EE* and the 50x60-in. platform *G*. *HH* are two 2-in. pipes serving to spread the wires *BB* for the better support of



DETAILS OF BRIDGE CONSTRUCTION

the platform, as shown in the plan. The wires *CC*, besides helping to support the platform by passing through the top pipe of the railing *K*, serve also as hand ropes, being placed about 30 in. apart.

The main purpose of the ropes *DD* is to prevent undue swinging of the bridge while the screen is being lifted through the 30-in. opening in the platform. *LL* are heavy single-strand wires which secure the planks to the ropes *CC*, as is best shown in the right-hand sketch. They serve to equalize the strain on the upper and lower wires. As the wires are all galvanized they should last many years.

R. O. RICHARDS.

Framingham, Mass.

Engineers and the Central Station

The New York Edison Co. has been directing its advertising in POWER recently at the engineer rather than the owner. Through suggestions that by recommending the Edison service to their employers they can "get away from the disagreeable details" improve their condition and "get in on the executive side of the job" the Edison Co. is trying to get engineers by their own recommendations to let the Edison service in—and themselves out.

The engineer is apt to have less work to do and to get more time for self-improvement when the Edison service comes in, but his pay is apt to stop at the same time with the work, and self-improvement does not buy shoes for the children.

Any city plant of such size that the salary of a competent engineer will not be disproportionate to the output,

and which has use for its exhaust steam can make light, heat and power cheaper than the central station can make and distribute it. Any owner of such a plant who allows himself to become involved in a long contract with the central station is losing money, and the engineer is losing money, too, for, notwithstanding all the talk about getting in on the executive side of the job, cases are not in evidence where the engineers are getting more money for pulling Edison switches than for intelligently administering a complete power plant.

The writer recalls one case in which Edison service was substituted for the private plant and the engineer was retained to run the heating plant. He advised his employers that it would be more economical to operate their own light and power plant which was already installed, and supply the entire service. The York Service Co., a subsidiary of the New York Edison Co., made a bid to operate the plant for a fixed annual charge and got it. The engineer had to get out.

In another case a plant of about 500 hp. was being sought after by the central station, although the operating engineer did his best to induce the owners to continue operation. They would not listen to his argument, however, and the Edison Co. have a contract, a short one I believe, to supply the electric current. The steam part of the plant has to be run for manufacturing purposes as well as heating in winter, but a cheaper man can do this. The engineer now has to look for another position.

These are both fine examples of graduating to the larger and more productive side of the job, but perhaps it is only those who advise the employer to scrap his plant and use Edison service that are thus qualified.

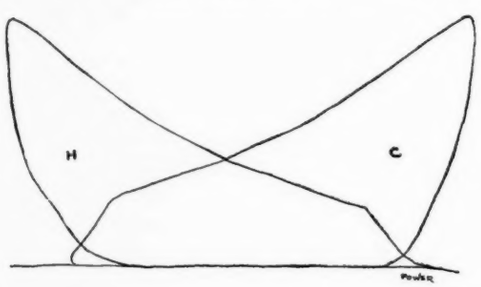
We hear much of the new buildings equipped with, and old plants shut down in favor of, Edison service. But we hear little of the new buildings in which plants are installed or those who resume plant operation after finding Edison service more expensive.

WILLIAM PECKHAM,
President, National Power Plant Assn.

New York City.

How Were the Diagrams Taken?

The diagrams herewith shown were taken from a 22x48-in. Allis-Chalmers, first-motion, Corliss valve, duplex hoisting engine, which is equipped with air brakes and reversing gear and drives two drums—one cage going up while the other goes down. It hoists up a



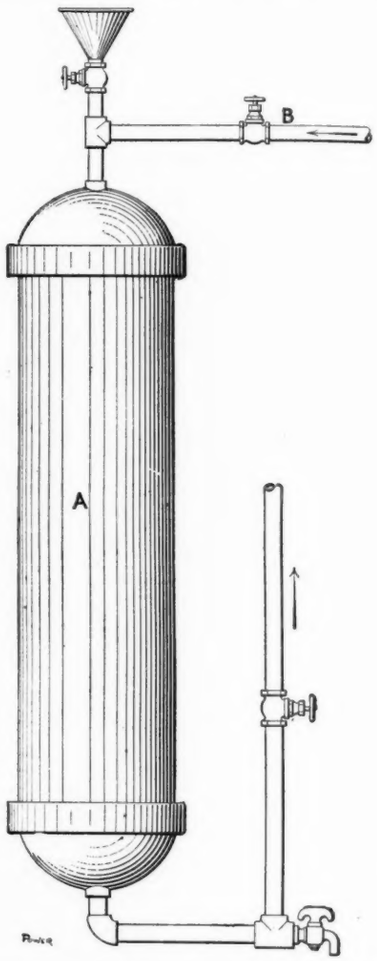
1500-ft. slope, one car every minute. The engines are new and in first-class condition. How were the diagrams taken?

W. H. BROOKS.

Franklin Furnace, N. J.

Another Boiler Graphite Feeder

To make this graphite feeder, I took an old cylinder (*A*) strong enough to stand a pressure of 150 lb. and connected it with a ¾-in. pipe (*B*) from the first section of our feed-water heater to the top of the cylinder; an air cock on the top of the cylinder is used to keep the tank from becoming air-bound. At the bottom of the cylinder is a ½-in. connection, with a cock, to draw off as much water as is required; also a 1-in. pipe, fitted with a valve, discharging from the bottom of the cylinder directly to the boiler-feed line. A funnel is provided to



GRAPHITE FEEDER USED WITH FEED-WATER HEATER

facilitate the pouring in of the mixed water and graphite.

The reason for taking water from the first section of the feed-water heater is that the water there is much cooler, which assists in giving the compound a rapid circulation through the cylinder and into the feed line, where the water is much hotter.

I find this way of putting the compound into the boilers in liquid form very satisfactory, the compound feeding through quickly when the water in the first section of the feed-water heater is cooler than that discharged from the compound cylinder into the feed line. If the water is of the same temperature, it will take longer to deliver the compound from the cylinder into the feed line.

LEWIS CARR.

New York City.

Trouble with Hot-Water Piping

In our ten-story office building we have a hot-water circulating system, the water being heated in a large iron tank in which there is arranged 36 ft. of 4-in. brass pipe. Through the brass pipe are circulated the vacuum returns. In the opposite end of the tank there are 36 ft. of 3-in. brass pipe in which the exhaust is circulated to help do the heating. The water is maintained at a temperature of 160 to 170 deg., and is kept under circulation continuously under a pressure of 90 lb.

Our principal trouble comes from the pipe lines giving out, and also the tank which has been renewed once. Renewing the tank is not so bad, but when it comes to the lines, which are in nearly every case buried in the floors, and in many cases in tile floors, it means a bad job. Is there any way in which we can safely clean these lines without taking up the piping? The pipes, of course, become well stopped up with barnacles and in some cases give out. The tank is cleaned regularly. We use city water which is from the Susquehanna River. It is filtered by the sand process and alum is added. Any information on the subject will be greatly appreciated.

ASA P. HYDE.

Binghamton, N. Y.

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Diagrams from Poppet-Valve Engines

The accompanying diagrams taken from old-style poppet-valve engines may prove of interest to readers. Figs. 1, 2, 3 and 4 are from a very old-style engine, with double-seat poppet valves and was originally operated at 50 r.p.m.

It was installed in two or three different plants before reaching the plant at which these diagrams were taken, and, during the vicissitudes of its career, the governor had been adjusted so as to give a speed of 75 r.p.m. This was in excess of the power requirements of the last plant as is evidenced by an inspection of the diagram.

The port openings for both steam and exhaust valves are 2⅝ in. at the bottom and 2⅞ in. at the top, giving a port area of 11.9 sq.in. The result of this is plainly shown by the exhaust line, especially that part from the point of relief to mid-stroke. The back-pressure line has been drawn on each card and represents the actual pressure in the 6-in. exhaust pipe at about 3 ft. from the cylinder.

Diagram 1 shows the valve setting as it was originally found, while diagrams 2 and 3 show the successive steps in the setting of these valves, and diagram 4 was taken after the valves had been ground in and as much of the lost motion in the valve-gear taken up as circumstances would permit.

Diagrams 5, 6 and 7 are also from an old-style engine built some time in the sixties. This engine had poppet-admission valves actuated through the governor and plain slide exhaust valves located beneath the cylinder and actuated by an eccentric on a shaft beneath the crosshead guides, and driven through a pair of double gears from the side or lay shaft.

Diagram 5 shows the valve setting as found and with the engine carrying a light load, while diagram 6 was taken under normal load. Diagrams 5 and 6 were taken with a 50-lb. spring, while diagram 7 was taken with a 30-lb. spring and shows the valve setting corrected.

The governor and entire valve motion were in a deplorable condition, and, as the principal object of indicating was to determine the possibility of making this engine do an additional amount of work while an entire new plant was installed, no repairs whatever were attempted. With the steam pressure increased to 100 lb., this engine carried a load of 160 hp. for three months, when the new engines were installed.

CHARLES L. WARE.

Maynard, Mass.

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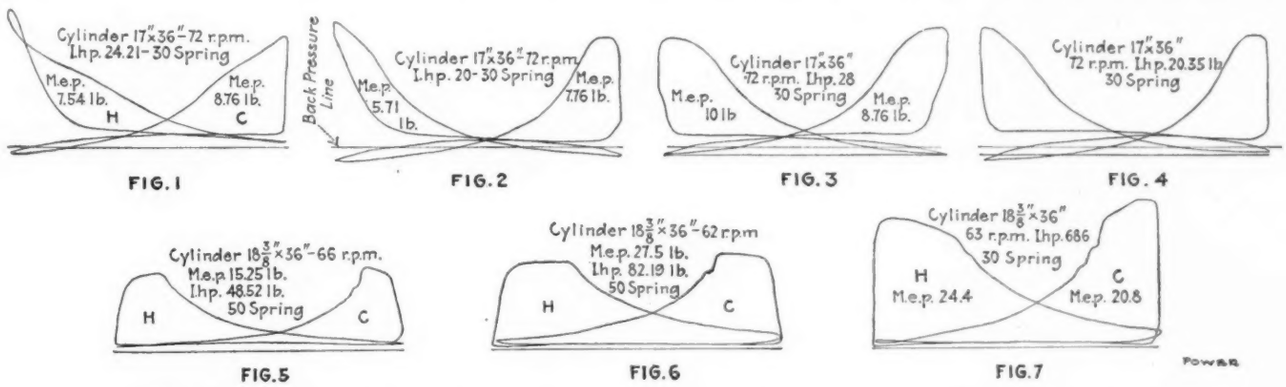
Mud in Steam

Mud in boilers is common, but mud in steam lines is new to me. We have two 150-hp. return-tubular boilers operated together. Feed water is taken from a creek of apparently clear water, but we have considerable trouble with what appears to be mud in the steam lines. It is particularly troublesome on the pumps, coating the tappets and stopping the pump. I have taken a teaspoonful of sediment out of the tappet chest and inside of an hour taken out another.

The inside of the steam chests on all pumps and engines is coated with a similar substance. We scraped about a quart out of the steam chest in a 24x27¼-in. cylinder a couple of days ago, and only got about half of it out at that. It also affects the action of the governor on a high-speed lighting unit, because this mud gets in the steam chest and keeps the valve dry; oil seems to have very little effect on it.

I saw a ½-in. steam line filled after standing unused for two or three weeks, and the line had to be taken down and cleaned out before steam could get through it.



DIAGRAMS FROM OLD POPPET-VALVE ENGINES, SHOWING EFFECT OF ADJUSTING VALVE-GEAR

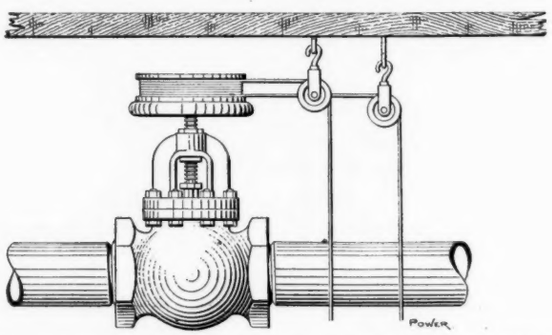
A duplex pump is located underground, and the exhaust steam was a source of annoyance, so we piped the exhaust into the suction, making the pump act as its own condenser, this solved the steam problem, and things went along nicely for about two days, when it was necessary to repack the plungers, upon taking off the follower, not a sign of the old packing was in evidence; the plungers were as bare as the day they were made, and that was the case for some time. The packing would disappear in two or three days.

We finally came to the conclusion that this was because the pump was not closely watched and because of a small sump. The pump would run out of water every once in a while and the steam entering the water cylinder would burn out the packing or soften it so that it would separate. We piped the exhaust to the atmosphere and have since had less packing to do.

White Horse, Y. T. H. TALBOT.

Manipulating Overhead Valve from Floor

A valve in our plant must be opened and closed many times a day. To do this, one must climb a ladder, as the valve is connected in a line that "hugs" the ceiling. To save myself the labor of climbing the ladder, I improved



OVERHEAD VALVE OPERATED FROM FLOOR BY CORD

the valve in the following manner:

From a large block of wood a flanged drum was made to be fastened to the handwheel of the valve. A ⅜-in. rope was wound around the drum and run through small pulleys, from which it dropped nearly to the floor. By simply pulling on the ropes the valve can be opened or closed from the engine-room floor.

Holly, N. Y. MARTIN MCGEERY.

Saved Engine Oil

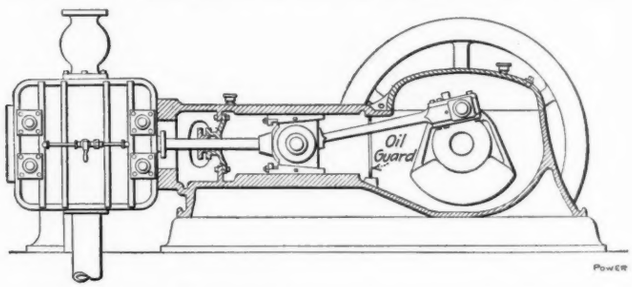
In a small plant the oil consumption of a four-valve, splash-oiled engine was extremely high. A pail was always kept under the oil stuffing-box to catch the drip and as all oil so secured was run through a filter it looked as if most of the oil was being saved. Quite a stream of oil came through this stuffing-box, which was difficult to pack satisfactory. Most packings contain rubber and such would soon be destroyed by the action of the oil. Packings containing no rubber were tried with but little better results, as the box was so shallow it was impossible to get in a sufficient amount to hold tight.

A new piston rod was put in and metallic packings were used, one for the steam and the other for the oil stuffing-box. The results were disappointing, as the oil came through almost as persistently as before, although the steam-rod packing worked satisfactorily and both sets were identical. No mechanical defects were apparent on the oil packing and after 30 days' running there was but a very slight improvement.

Various grades of oil were tried with but little difference in the result. It was then observed that when the engine was operating a light smoke continually issued from the two top ventilators of the engine frame. A finger rubbed on a window or hand rail in the engine room showed the presence of oil, and it was apparent that oil was vaporizing. As the engine was completely inclosed it was supposed that the oil got hot after a short run. At the close of a ten-hour run a thermometer was placed in the oil at the bottom of the engine frame, but it registered no more than 110 deg. F. Surely 110 deg. would not vaporize the oil. Cylinder oil was then tried and it was the same story over again.

Because so much oil worked past the oil packing it showed that considerable oil was thrown against this point by the rapidly moving parts dipping in the oil, and a good deal of this oil came in contact with the hot piston rod, hence vaporization. The problem then was to prevent the oil from getting back to this point.

In this engine the greater part of the oil is thrown by the engine crank and something like 90 per cent. would miss the crosshead and be thrown to the rear of the frame



SECTION OF ENGINE FRAME, SHOWING OIL GUARD

where the crosshead splashed it on the rod, when it would work out through the stuffing-box.

After various experiments a sheet-iron plate was placed across the frame close to the engine crank. It was tightly fitted to the sides of the frame and in the center just enough space was left to permit the connection rod to work freely. This formed a partition that prevented oil getting to the crosshead and other parts except what was thrown through the slot in the plate. After this change the fog ceased coming from the ventilators and only occasional drops from the stuffing-box; further, a very material drop in oil consumption was accomplished. For instance, in a 269-hour run, 45 gal. of oil were used before the change, or six hours per gallon of oil. After the change but 4 gal. were used for 143-hour run, or 35.7 hours per gal. of oil. This saving in the amount of oil well repays the effort expended.

The oil people let us have their expert engineer who spent a day with us and materially assisted in making this saving. The engine was watched carefully for the next few days for signs of insufficient lubrication, but it appeared to be getting all it required, and after 60 days' operation, no bad effects have been observed.

Geneva, Neb. G. S. SPRAGUE.

QUESTIONS BEFORE THE HOUSE

Wavy Lines on Pump Diagrams

In reply to S. F. Reynolds' query, in the Apr. 8 issue, as to what causes the wavy suction lines on his pump diagrams, I would suggest as follows:

In the first place this wavy line is due to the fact that the suction pressure is not constant at that part of the stroke which is shown from the diagram to be the beginning of the stroke. This is, no doubt, due to the sudden reversal or stoppage of the movement of the water column, which occurs in all reciprocating pumps at the end of each stroke. This sudden stoppage causes fluctuations in the suction pipe and vacuum chamber, which momentarily bring the suction pressure first up, then down, giving the wavy line as shown. These irregulatities may be decreased by using a vacuum chamber in the suction line of the pump, but can probably never be entirely eliminated. The writer has never seen a pump diagram in which the suction line was entirely free from "waves."

GRANDON D. GATES.

Seneca Falls, N. Y.

Thermometer and Mercury-Column Readings on High-Vacuum Condensers

In the Dec. 31 issue, page 984, is a letter from James L. Haynes, discussing an article on the above subject that appeared in the Nov. 19 issue. I wish to submit the following comment on Mr. Haynes' letter:

Since most of the air in the condenser seeps in through the pores of the condenser and the exhaust piping and their joints, particularly the latter, the percentage of air present in the steam at the exhaust nozzle of a steam turbine is negligible. If an accurate thermometer is placed either in the exhaust nozzle of a turbine or in the exhaust piping leading to the condenser and so inserted that it is subjected to the action of the flowing steam, not being placed where a pocket of air can form, it will give the temperature corresponding to the absolute exhaust pressure at that point more accurately than the average or ordinary mercury column. This will eliminate correcting for the barometric pressure, the difference of elevation between the barometer and the mercury column, using the correction constant of the barometer if an aneroid is used, and correcting for the temperature of the mercury and the scale used and for the capillarity of the glass tube, aside from any accidental errors.

However, the metal-case thermometer used must be accurate and placed near the turbine-exhaust nozzle and so designed that the mass of the metal case is small so as not to give too great a time lag to the thermometer registration. Also the metal case which screws into the piping wall should be insulated from the thermometer to prevent error, due to the heat flowing from the hotter walls of the turbine cylinder.

Incidentally a thermometer is more sensitive for high vacuum (see Table 1, in Marks & Davis "Steam Tables").

While with a reciprocating engine the exhaust steam may be superheated, due to the reëvaporation at a lower pressure of the steam initially condensed on the cylinder walls, with a turbine and its continuous flow of the steam, there is not much chance of getting any superheat in the exhaust steam, under any commercial conditions of operation.

Steam Pressure Lb. Absolute	Gage	Initial Superheat Deg. F. Necessary to Get Superheat in the Exhaust Steam						
220	205.3	430	570					
200	185.3	410	550					
180	165.3	390	530					
160	145.3	370	500	650				
140	125.3	340	470	620				
120	105.3	...	430	580	650			
100	85.3		390	540	600	700		
80	65.3				480	570	630	
60	45.3				390	480	530	630
40	25.3					420	470	560
30	15.3							380
15	0.3							
Absolute exhaust pressure pounds./0"	14.7.	8	4	3	2	1.5	1.0	0.75
Vacuum inches hg.	Atmos.	4"	21¼"	23"	25"	26"	28"	29"

700
630
460

Note—These values were taken from the Mollier chart in the Marks & Davis book of steam tables.

The turbine-efficiency ratio on the Clausius (Rankine) cycle will run from 50 to 80 per cent., and the heat losses, due to bearing friction and to the residual velocity in the exhaust steam, do not affect the expansion of steam in the blading nor the quality of the exhaust steam, so that, for all practical purposes, we can consider the exhaust steam as not being superheated.

The accompanying table gives the necessary superheat in the steam for the exhaust steam to be superheated, assuming a barometric pressure of 14.7 lb. per sq.in. and adiabatic (perfect) expansion.

CHARLES K. CARPENTER.

Ithaca, N. Y.

Another Blowoff-Tank Explosion

In the Mar. 4 issue appears an account of a blowoff-tank explosion which is similar to an accident that happened here recently.

We have two boilers, the blowoff pipes of which enter a common blowoff tank placed just outside the boiler-room wall, with the top of the tank about 2 in. below the ground level. This tank is cast iron 3 ft. in diameter and 3 ft. deep with a 4-in. pipe to the city sewer and a 2½-in. vent pipe fastened to the wall outside and rising 2 ft. above the roof. The pipes from the boilers to the tank are 2½ in. in diameter.

One morning, on blowing down a boiler under 75 lb. pressure, I had opened the blowoff valve about three-quarters of the way when there was a loud explosion outside of the building. Shutting the valve I found that the tank cover had been blown off. This cover was about 1 ft. in diameter and fastened to the top of the tank with six ⅜-in. bolts. These bolts had, with one exception, pulled through the top of the tank by breaking off pieces of the

head from the bolt-hole circle to the inner rim. One bolt held and with it was a piece of cover 3 in. in diameter. The rest of the cover, which weighed 15 lb., I found on the other side of three railroad tracks 160 ft. from the boiler room.

The real cause of the explosion has never been explained to me. It was a cold morning and ice might have formed in the pipe to the sewer or the pipe might have been obstructed in some other way, but it was unobstructed on the evening before, as was the 2½-in. vent to the atmosphere.

Perhaps some reader of POWER could give an explanation as to the cause of this accident.

L. H. STARK.

Delevan, Wis.

Use of Fuel Oil

Your editorial in the Jan. 14 issue, on "Use of Fuel Oil" appeals to me, as this question has been prominently before the engineers of this part of the country for several years.

Fuel is high priced at this point, there being no wood, and the poorest kind of slack costs $3 laid in the bin. Therefore, most steam plants in this vicinity are burning oil and engineers in this locality have done a great deal of experimenting as regards furnace design and arrangement. As for choice of burners, there have been only three different designs procurable. We have read everything available on the subject, which was very little.

Of course, the manufacturer of each burner gives his own product a flattering recommendation. Therefore I have a suggestion to make, which, if followed, should be of benefit not only to the oil dealers, but to the engineers who are using, or who may be contemplating the use of oil as a fuel. My plan would be, not for the manufacturers of the burners to get out a lot of literature on the subject, as they would be naturally prejudiced in favor of their own burners, but for the oil dealers' association to carry out the suggestions of your editorial by having a large number of blank forms printed, and distributed among engineers of power plants where oil is used for fuel, the printed forms to have a space for descriptions of the furnace design employed in each test made, and having the essential headings, such as temperature of oils, pressure of oils, pressure of steam used on the burner, position of dampers, ash doors, water evaporated per gallon of oil, and all practical details, though not going into such technical points as flue-gas analysis, etc., as very few engine rooms are equipped with instruments for obtaining such information, and reference to unnecessary refinement might discourage users of fuel oil from making returns of valuable practical data.

These blank forms should then be distributed among the oil-burning engineers in all sections of the country. The kind of burner used, and all other leading practical details regarding the oil system used should be included in the report forms. When these reports were returned to the associations, they could be summarized in the form of a circular for the mutual benefit of the oil dealers and their customers and sent out to users and prospective users of fuel oil. In doing this the association would not be showing partiality to any make of burner, and each engineer could see just what others were doing and how it was being done, and the movement would be bound to procure hundreds of new customers for the oil dealers.

Those already equipped with burners could remedy their faults and those contemplating the use of oil as a fuel could have the benefit of the experience of all the rest as a guide to their own choice of burner, and to their preferences in furnace designs.

If the association would not set this plan on foot, I believe it would be very helpful to engineers were the different engineers over the country to send such reports to POWER, and thus enable all interested to secure very comprehensive data on the subject.

JOHN PIERCE.

Kiowa, Kan.

[Our correspondent has offered some very sensible recommendations for putting the suggestions of our editorial into practical operation and it is to be hoped that the dealers in fuel oil will avail themselves of the opportunities referred to. Whether or not any action is taken by the dealers we will be glad to give space in the columns of POWER to any data that may be of value to those of our readers who are interested in the subject of fuel oil.—EDITOR.]

Blowoff Cock Explodes

The account of a piston explosion as described on page 321 of the Mar. 4 issue reminded me of a similar accident in our plant.

A blowoff pipe had split and the pipe fitter found it necessary to heat the blowoff cock to get it off after the pipe and cock had been removed from the boiler. The plug of the cock must have contained water, because soon after being placed in the forge, an explosion occurred, destroying the blowoff cock and doing considerable damage to the shop. Fortunately, no one was seriously injured.

B. S. HANSON.

Broad Brook, Conn.

Flow of Water over Weirs

B. D. Moses has made some serious errors in his article on the above subject, on page 258 of the Feb. 25 issue. In his treatment of the triangular weir he states that the discharge may be represented by a volume the value of which is

$$\tfrac{8}{15} K \sqrt{2gh}$$

where K is the ratio $b/2h$. He then states that if $K = 1$, then

$$Q = \tfrac{8}{15} \sqrt{2gh^{\frac{3}{2}}}$$

which is not consistent with the first equation.

[The placing of $h^{\frac{3}{2}}$ under the radical sign in the above formula, as given in Mr. Moses' article, was not the author's error, but was a typographical one.—EDITOR.]

Then introducing a coefficient of discharge of 0.6 he obtains

$$Q = 2.56\, h^{\frac{3}{2}}$$

which is not consistent with either of the above equations. None of the three are correct.

The volume in question has the value

$$\tfrac{8}{15} K \sqrt{2g}\, h^{\frac{5}{2}}$$

and, if $K = 1$ for the 90-deg. notch, then

$$Q = \tfrac{8}{15}\, h^{\frac{5}{2}} \sqrt{2\,g}$$

introducing the coefficient of discharge of 0.6 then

$$Q = 2.56\, h^{\frac{5}{2}}$$

The value of the coefficient used is probably close enough for most purposes, but the more common value is

$$Q = 2.54\, h^{\frac{5}{2}}$$

For a discussion of that point see POWER, Sept. 20, 1910, page 1684.

At the end of the article Mr. Moses states that the Francis formula for suppressed weirs is

$$Q = Cbh$$

in which C is a coefficient depending upon the number of contractions. In the first place a suppressed weir is one that has no contractions. The Francis formula for the suppressed weir is

$$Q = 3.33\, bh^{\frac{3}{2}}$$

The Francis formula for the weir with end contractions is,

$$Q = 3.33\ (b - 0.1\ nh)\ h^{\frac{3}{2}}$$

in which n is the number of contractions, usually two, though occasionally one may be encountered.

R. L. DAUGHERTY.

Ithaca, N. Y.

Should the Engineer Be Factory Fire Chief?

The editorial on the above subject in the Dec. 21 issue takes the correct position; but it might have treated the subject at greater length. Preventing loss by fire is so important in factories that it is worth discussing to some extent. The latest figures show that fire losses in the United States during 1912 reached 220 to 250 million dollars. Although this does not cover the losses of all fires, nevertheless, it is sufficient to stimulate anyone to action, especially if he is connected with manufacturing establishments, where the loss in any one case is generally very large.

The extent of the loss of human life has not been pointed out here; but the safeguarding of life should be the chief reason for fire prevention. From the way in which even ordinary precautions are sometimes ignored or violated, is it surprising that many factory owners have been put on trial for criminal negligence after a fatal fire in their establishments? If the risk of destruction by fire were to be reduced or the possibilities for the spreading of a fire reduced to a minimum, the rate of insurance would be lowered; the employees would, probably, work at a higher efficiency because the fear of a panic would be remote.

When a fire breaks out, the engineer is likely to be in the power house, which may be some three hundred feet from the main building. What is needed is not so much a single man who will act as fire chief, but a number of men well distributed about the plant, who will always be present to take immediate command of the workers in case of fire.

Whenever a fire alarm is given, it should be sounded in all parts of the property where the engineer might be, so that he could hurry to his post in the station and direct his men in their part of the fire fighting, which should be confined to the management of the fire pump, etc.

The engineer should also test all fire pumps at regular intervals to insure perfect readiness and prompt response in time of need, as well as inspect or suggest fire appliances about the plant.

ALBERT H. ISRAEL.

New York City.

[It was not our purpose to summarize editorially the means for fire prevention, as that is out of our field. Our aim was and is to stop the practice of adding to the responsibilities of the engineer by appointing him to assume the responsibilities of the factory fire chief.—EDITOR.]

Discussion of Oil-Flow Problem

In reply to the letter of H. O. McCarthy, in the Apr. 8 issue, as to why the new arrangement of piping causes the storage tank to fill with oil more quickly, I offer the following two suggestions:

With the new arrangement there is no direct connection between the tank wagon and the storage tank, while in the first case the oil was piped directly from the wagon. Possibly in the first case sufficient air did not reach the tank wagon to replace the oil flowing out, thus reducing the pressure on the oil in the wagon sufficiently to greatly retard the flow of the oil. When the open connection was made, air was more easily let into the wagon, thus increasing the flow. The increased size of the pipe in the new installation would not account, of itself, for the increased flow.

It is also possible that with the old arrangement of the closed circuit some entrained air was in the storage tank when the connection was first made. As the oil flowed in from the wagon this air was compressed and its pressure tended to retard the flow. With the open connection of the new arrangement the air escaped into the atmosphere, and all liquid surfaces were subjected to atmospheric pressure.

GRANDON D. GATES.

Seneca Falls, N. Y.

Engine Ratings

Probably many readers of POWER, like myself, would like to have others shed some light on the question of rating steam engines.

(1) If we take a modern high-speed engine, say 10x10, rated at 65 i.hp., making 350 r.p.m., taking steam at 100 lb. boiler pressure and cutting off at ⅓ stroke, then with all conditions the same, except that the engine is loaded, requiring cutoff at ½ stroke, will it develop the increased power and give steady duty without undue heating of the bearings?

(2) Can continuous duty be obtained from this same engine developing 65 i.hp. running 250 r.p.m. supplied with steam at 100 lb. boiler pressure and cutting off at about ½ stroke?

(3) Or when developing 70 i.hp. running 375 r.p.m. and cutting off at about ⅓ stroke?

Assuming that the engine has proper proportions so that the different conditions of running will not affect the strength of the materials, the adaptability of the engine to the conditions proposed would seem to resolve

itself to the question of heating of the bearings. It should be noted that in condition (1) we would increase the power by continuing the initial pressure for a longer period of the stroke; in (2) we have maintained the nominal power by increasing the cutoff and decreasing the revolutions per minute, while in (3) we have increased the indicated horsepower by increasing the revolutions per minute.

The remaining question is: What provision do engine builders make for the varying conditions? Do they adhere to standards and furnish an engine that falls within those standards or do they proportion parts only for the conditions most favorable to the bearings?

Doubtless readers of POWER who are users of high-speed engines will be mutually benefited by an interchange of experiences in running such engines at speeds and loads different from the cataloged ratings.

ROBERT GILSON.

Buffalo, N. Y.

How Exhaust Valves Got Inverted

In reply to F. A. Hunter's inquiry as to how the exhaust valves got turned upside down as asked in the Mar. 25 issue, I would advise that there are only two ways that it could happen if the lines on the valves and cylinder coincide as they should.

One way is for the line to extend clear across the valve, but this is hardly probable as I never saw or heard of such a manner of marking a valve. The other way is for marks on the valves to be at 90 deg. to a center line drawn perpendicularly through the valve when the wrist-plate is on the center. The valves under discussion were marked on the side nearest the exhaust-pipe connection, as shown in Mr. Hunter's illustration. If both valves were removed at the same time it would be easy to get them mixed and, when putting them back, to put valve *A* in valve *B's* place when the valve would have to be upside down for the lines to match.

GEORGE P. BRANN.

Grinnell, Iowa.

Shall We Let the Foot-Pound Wabble?

C. P. Poole, in the issue of Mar. 18, mentions the question "whether it is more expedient in scientific work to take 746 as the exact equivalent (of the horsepower in watts) and let the foot-pound values wabble, or *vice versa*." There is no need of having either the horsepower or the foot-pound wabble if we define the horsepower as 550 foot-pounds per second and as equivalent to 745.70 watts, which is the correct value to the fifth significant figure, if we define the pound force as the force which will give one pound of matter an acceleration of 980.665 cm. (=32.1740 ft.) per second, this acceleration being that produced by gravity at latitude 45 deg. at the sea level. With this value 1 kw. = 1.3410 hp., correct to the fifth significant figure.

He says also "the common pound and ounce weights have not the same absolute values at all latitudes." This is true only if he means by pound weight not a certain piece of metal but the attraction of gravity on that piece of metal. The piece of metal has the same value, that is, quantity of matter at all latitudes, and the quantity is determined by weighing it on an even balance scale against a standard piece of metal, known as the standard pound, at any latitude whatever.

I agree with him that 746 watts and 550 ft.-lb. per sec. will always be used as horsepower equivalents in ordinary everyday work, just as 1.34 hp. will be used as the equivalent of a kilowatt, but for accurate scientific work the figures that should be used are 745.7, 550 and 1.341.

Mr. Poole once criticized the table of equivalent values given on page 1347 of my pocketbook, tenth edition, as being in some respects inaccurate. I have had a new plate made with the figures corrected, and inclose a proof. You will see that in it I make 1 hp. equal 745.7 watts. I shall be glad if you will reprint this table.

New York City. WILLIAM KENT.

[We appreciate the privilege of reprinting this table as we know it will be useful to many of our readers. Any who have the older edition of Professor Kent's "Mechanical Engineers' Pocket Book" will do well to preserve this table in it.—EDITOR.]

EQUIVALENT VALUES OF ELECTRICAL, MECHANICAL AND HEAT UNITS

Unit	Equivalent Value in Other Units
1 Kw.-Hour =	1,000 watt-hours 1.341 horsepower-hours 2,655,220 ft.-lb. 3,600,000 joules 3415 heat-units 367,100 kilogram-meters 0.234 lb. carbon oxidized with perfect efficiency 3.52 lbs. water evaporated from and at 212° F 22.77 lbs. of water raised from 62° to 212° F
1 Hp.-Hour =	0.745.7 Kw.-hour 1,980,000 ft.-lb. 2546.5 heat-units 273,740 kg.-m. 0.174 lb. carbon oxidized with perfect efficiency 2.62 lb. water evaporated from and at 212° F 17.0 lb. water raised from 62° F. to 212° F
1 Kilowatt =	1,000 watts 1.3410 horsepower 2,655,220 ft.-lb. per hour 44,254 ft.-lb. per minute 737.56 ft.-lb. per second 3415 heat-units per hour 56.92 heat-units per minute 0.9486 heat-units per second 0.234 lb. carbon oxidized per hour 3.52 lb. water evaporated per hour from and at 212°

Unit	Equivalent Value in Other Units
1 Hp. =	745.7 watts 0.7457 Kw. 33,000 ft.-lbs. per minute 550 ft.-lbs. per second 2,546.5 heat-units per hour 42.44 heat-units per minute 0.707 heat-units per second 0.174 lb. carbon oxidized per hour 2.62 lbs. water evaporated per hour from and at 212° F
1 Joule =	1 watt second 0.000000278 Kw.-hour 0.102 kg.-m. 0.0009486 heat-units 0.73756 ft.-lb.
1 Ft.-lb. =	1.3558 joules 0.13826 kg.-m. 0.0000003766 kw.-hour 0.0012861 heat-unit 0.0000005 hp.-hour
1 Watt =	1 joule per second 0.001341 hp. 3.415 heat-units per hour 0.73756 ft.-lb. per second 0.0035 lb. water evaporated per hour 44.254 ft.-lb. per minute
1 Watt per sq. in. =	8.20 heat-units per sq.ft. per minute 6373 ft.-lb. per sq.ft. per minute 0.1931 hp. per sq.ft.

Unit	Equivalent Value in Other Units
1 Heat-unit =	1054.2 watt-seconds 777.54 ft.-lb. 107.5 kilogram-meters 0.0002928 kw.-hour 0.0003927 hp.-hour 0.0000685 lb. carbon oxidized 0.001030 lb. water evaporated from and at 212° F
1 Heat-unit per Sq. Ft. per min. =	0.1220 watt per sq.in. 0.01757 kw. per sq.ft. 0.02356 hp. per sq.ft.
1-Kilogram Meter =	7.233 ft.-lb. 0.000003653 hp.-hour 0.000002724 kw.-hour 0.009302 heat-unit
1 lb. Carbon Oxidized with perfect Efficiency =	14,600 heat-units 1.11 lb. anthracite coal oxidized 2.5 lb. dry wood oxidized 22 cu.ft. illuminating gas 4.275 kw.-hours 5.733 hp.-hours 11,352,000 ft.-lb. 15.05 lb. of water evaporated from and at 212° F
1 lb. Water Evap. from and at 212° F =	0.2841 kw.-hour 0.3811 hp.-hour 970.4 heat-units 104,320 kilogram meters 1,023,000 joules 754,525 ft.-lb. 0.066466 lb. carbon oxidized

INQUIRIES OF GENERAL INTEREST

Fitting Piston Rings—When new piston rings are in position how far apart should the ends be?

A. P.

About $^5/_{64}$ in. for a cylinder of average size.

Pump Slip—What allowance is usually made for slip in pumps?

E. S.

For new pumps working at normal speed 5 per cent. is usually allowed for slip.

Bypass Valve—What is a bypass valve and what is it for?

J. P.

A bypass valve is a gate or disk valve (usually) with a bypass or outside connection, containing a small stop valve, between the spaces on the sides of the disk. The bypass valve is for use in large mains as a stop valve against considerable pressure. The bypass makes it easier to open or close the main gate because it equalizes the pressure on the two sides of the gate.

Testing for Piston Leaks—How should a steam-engine piston be tested for leaking?

I. W. T.

One head should be taken off and steam admitted to the other side with the piston at each end of the stroke and also with the piston blocked at mid-stroke and preferably several intermediate positions. This will detect unequal wear, as at the center of the cylinder or over any soft spots in the cylinder metal.

Altitude and Boiling Point—Is it true that the boiling point of water (212 deg. F.) declines one degree for each 1250 ft. of elevation above sea level?

E. S.

As each 1000 ft. of elevation results in a reduction in atmospheric pressure of very closely ½ lb., then, by interpolating values given in Marks and Davis steam tables, it may be found that at the first 1250-ft. elevation water would boil at 209.82 deg. F., and for the second 1250 ft., i.e., at 2500 ft. above sea level, at 206.95 deg. F., so that the reduction of the boiling point is not 1 deg. per 250 ft., nor does it vary directly in proportion to the elevation above sea level.

Feed Through Blowoff—In a certain plant the boiler has a combination blowoff and feed pipe. The engineer claims that he has had no trouble with the arrangement and that he is able to keep his blowoff pipe clean. Is it good practice to feed a boiler in this way?

S. R. B.

Feeding through the blowoff to keep the latter open is very old. It is objectionable where the constant discharge tends to wear out the blowoff connections due to the scouring action of gritty feed water, for it may bring about the disabling of the feed connection at a place where it is not readily detected.

Tank Diameter—What will be the diameter of a cylindrical tank 68 in. high, having a capacity of 50 liters?

H. V. W.

One liter is equal to one cubic decimeter, which is equal to 61.023 cu.in. Therefore, the tank contains

$$50 \times 61.023 = 3051.15 \text{ cu.in.}$$

Being 68 in. high, the cross-sectional area will be

$$\frac{3051.15}{68} = 44.86 \text{ sq.in.}$$

The area of a circle equals $0.7854\ D^2$, where D = diameter. Then

$$\sqrt{\frac{44.86}{0.7854}} = 7.55 \text{ in.}$$

is the required diameter of the tank or about $7\frac{9}{16}$ in.

Saving Heating Coil Returns—We have heating coils supplied with exhaust steam at 3 to 5 lb. pressure. No attempt is made to save the returns. The engine uses about a pint of cylinder oil in a 9-hr. day. Would it be advisable to return the condensation from the coils directly to the boilers?

J. V. N. C.

While most of the oil can be taken out of the steam by inserting an oil separator in the supply pipe to the coils, the remaining oil may be sufficient to do damage to the boilers. The proportion of oil that may be present without injury to a boiler is variable, seeming to depend on the analysis of the feed water. If used over and over, a considerable quantity of oil may be deposited, and if not thoroughly washed out, may cause the boiler sheet to be burned. By collecting the condensation first in a hotwell, much of the oil may be separated from the water fed to the boiler by putting the suction-pipe inlet well below the surface of the water.

Selecting Boiler for Given Engine—How is it known what size boiler will be necessary to supply an engine of a certain horsepower?

J. P.

In ordinary good forms of boilers 10 sq.ft. of heating surface will develop one horsepower with ordinarily good fuel, firing and draft. A boiler horsepower corresponds to an evaporation (equivalent) of 34½ lb. of water per hour. This is usually 30 lb. at the actual boiler pressure carried. The steam consumption of the engine under consideration is assumed to be known as so many pounds per horsepower-hour. This multiplied by the engine horsepower will give the pounds of steam required per hour. The latter divided by 30 will give the required boiler horsepower and the last named, multiplied by 10, will give the heating surface necessary. Boilers can be forced above their rated capacity easily so that overloads on the engine can be handled in that way, but it is common to provide a little excess boiler capacity so that forcing will not be called for.

Sizes of Plant Parts—We now have a 315-hp. motor load and want to add about 90 hp. in about a year. The motors are three-phase, 60-cycle, 440-volt. What size boiler, engine and generator are required?

C. M. M.

The total motor load will be

$$315 + 90 = 405 \text{ hp.}$$

which is equivalent to

$$\frac{405 \times 746}{1000} = 302 \text{ kw.}$$

Assuming an average motor efficiency of 88 per cent.

$$\frac{302}{0.88} = 344 \text{ kw.}$$

is the input to the motors.

Allowing 4 per cent. for distribution and line losses

$$\frac{344}{0.96} = 358 \text{ kw.}$$

is the required generator output.

A generator of this size would have an efficiency of about 92 per cent. Therefore,

$$\frac{358}{0.92} = 390 \text{ kw.}$$

must be put into the generator. This would correspond to a brake horsepower of

$$\frac{390 \times 1000}{746} = 522 \text{ hp.}$$

Say a 525-hp. engine would be required.

A compound engine of this size operated condensing would take about 18 lb. of steam per horsepower-hour

$$525 \times 18 = 9450 \text{ lb. of steam per hr.}$$

A boiler horsepower being about 30 lb. of steam per hr. the boiler horsepower required would be

$$\frac{9450}{30} = 315 \text{ b.hp.}$$

It would be preferable to have the boiler plant in two or three units, so as to always have one spare. Boilers can be run at 50 to 100 per cent. overload continuously when necessary, so that two 175-hp. boilers or three 125-hp. would be about right.

The above has assumed the motor load to be the maximum actual, not the sum of the normal ratings of the motors installed. If the latter was meant and only a certain per cent. of the total capacity is used at any one time all of the figures about given should be correspondingly reduced.

ENGINEERS' STUDY COURSE

Principles of Combustion—IV

Weight of Air Required

So far we have been talking about and figuring for the quantity of oxygen required for the combustion of the various elements.

The only cheap source of oxygen for the purpose of combustion is the air, which is free for everyone to use. The nitrogen of the air is an incombustible gas; that is, it will not burn with oxygen no matter how much it is heated, neither will it burn with any of the combustibles of the fuels. Hence, it is entirely useless for the purpose of combustion. But, there is no economical way of separating the oxygen from the nitrogen and as they are thoroughly mixed together we must supply the nitrogen to the fire along with the oxygen.

As the ratio by weight of nitrogen to oxygen is 76.85 to 23.15, for every pound of oxygen required we must supply

$$\frac{76.85}{23.15} = 3.32 \; lb.$$

of nitrogen and hence for every pound of oxygen required we must supply

Oxygen + Nitrogen = Air

1 + 3.32 = 4.32 lb. of air

Col. 8, Table I, gives the pounds of air required per pound of combustible in Col. 4. These figures may be used to shorten the work when figuring the air required.

If, instead of burning just a single combustible element, such as carbon or hydrogen, we burn a fuel containing both of these elements, we figure the oxygen or the air required for the amount of each element contained in one pound of the fuel just the same as though that element was the only one under consideration. The sum of the amounts of air required for each element then equals the amount of air required per pound of the fuel in question.

Thus, if we had a coal which contained, say 80 per cent. carbon; 5 per cent. available hydrogen; 2 per cent. sulphur; 1 per cent. nitrogen, and 7 per cent. ash; the air required would be estimated as follows:

Carbon contained in a pound of the coal equals 0.8 lb. From Table I, Col. 8, air required for complete combustion of one pound of carbon equals 11.52 lb. Then the air required for 0.8 lb. carbon equals

$$0.8 \times 11.52 = 9.216 \; lb.$$

The available hydrogen equals 0.05 lb. Air required per pound of hydrogen (Table I) equals 34.56. Air required for 0.05 lb. hydrogen equals

$$0.05 \times 34.56 = 1.728 \; lb.$$

Adding these two quantities together, we have

Air required for carbon in coal	9.216 lb.
Air required for available hydrogen	1.728 lb.
Air required per pound of coal	10.944 lb.

The air required for the sulphur in the coal we neglect as the amount of sulphur is small and, besides, the sulphur may already be combined with some other element and hence be incombustible anyhow. The ash and nitrogen, being incombustible, require no air.

A couple more illustrations of how the weight of air required for a given weight of fuel is estimated may assist to fix the method in mind more securely. Let us assume that we are burning a fuel oil in our plant which is composed of the following: Carbon, 82 per cent.; available hydrogen, 13 per cent.; moisture, 5 per cent. How many pounds of air are theoretically required for the combustion of this oil?

In every pound of the oil there is 0.82 lb. of carbon. Then, as one pound of carbon requires 11.52 lb. of air for complete combustion (see Table I, Col. 8) 0.82 lb. will require

$$0.82 \times 11.52 = 9.45 \; lb.$$

Then 13 per cent. of a pound (the amount of hydrogen contained in 1 lb. of the oil) equals 0.13 lb. Referring again to Table I, Col. 8, one pound of hydrogen requires 34.56 lb. of air and hence 0.13 lb. requires

$$0.13 \times 34.56 = 4.49 \; lb.$$

Adding the two quantities of air required, we have

Air required by carbon part of one pound of oil	9.45 lb.
Air required by hydrogen part of one pound of oil	4.49 lb.
Total air required per pound of oil	13.94 lb.

If we were burning a gas containing 70 per cent. carbon and 24 per cent. hydrogen, what would be the weight of air required per pound of gas?

Air required by the carbon in one pound of gas = 0.7 x 11.52 =	8.06 lb.
Air required by hydrogen in one pound of gas	8.29 lb.
Total air required per pound of gas	16.35 lb.

This same method of calculating the amount of air required by a fuel can be expressed in the form of a formula thus:

$$W = 11.52\,C + 34.56\left(H - \frac{O}{8}\right)$$

in which

W = Weight of air required per lb. of fuel;

C = Weight of carbon per lb. of fuel;

$\left(H - \frac{O}{8}\right)$ = Available hydrogen per lb. of fuel.

The available hydrogen is found by subtracting 1/8 of the weight of oxygen in the fuel from the total weight of hydrogen in the fuel—just as the expression in the formula indicates.

Suppose we had a fuel with this analysis: Carbon, 78 per cent.; total hydrogen, 7 per cent.; sulphur, 1.5 per cent.; oxygen, 4 per cent.; nitrogen, 1.5 per cent., and ash, 8 per cent. Substituting in the formula we have

$$W = 11.52 \times 0.78 + 34.56\left(0.07 - \frac{0.04}{8}\right)$$

or

$$W = 11.52 \times 0.78 + 34.56 \times 0.065 = 11.23 \; lb.$$

of air required per pound of fuel.

For those who wish to test their understanding of what has been set forth in the foregoing article and who wish practice in calculations involving percentages and decimal fractions, the following problems are offered:

Given a coal with the following analysis: Carbon, 78.75 per cent.; total hydrogen, 5 per cent.; oxygen, 2 per cent.; nitrogen, 2 per cent.; sulphur, 3.75 per cent.; ash, 8.5 per cent. Neglecting the sulphur, what is the weight of air required for complete combustion per pound of this coal? What would be the weight of the products of combustion?

Given a fuel oil containing: Carbon, 84.85 per cent.; available hydrogen, 11.15 per cent., and moisture, 4 per cent. What is the weight of air required per pound of oil and what would be the weight of the products of combustion?

A feed-water heater is handling 7575 lb. of water per hour. It raises the temperature of the water from 73 to 197.5 deg. F. How much heat is being put into the water per hour?

These problems will be fully worked out in the next article of this series which will appear next week.

Power Generation and Transmission in Industrial Works

In a paper on "The Layout, Design and Equipment of Industrial Works," read before the Liverpool Engineering Society, Andrew Home-Morton had the following to say concerning power generation and transmission:

Where the plant is compact and conveniently arranged within a radius, of, say, 100 or 150 ft., from the central power plant, mechanical transmission is most economical, while, with an increased radius, gas or electrical transmission has advantages, the former being the most enticing system from the point of view of thermal efficiency, but meantime having a more limited application.

Where tools are set widely apart, electrical transmission with individual motors is economical, although where it is possible to have a group of tools in a works, an independent gas engine or electric motor driving these through gearing is more economical than individual motors. Where the amount of power required for individual machines is small, it is almost always advisable to group them.

The question of reliability and consequent need for standby plant is also important. Practically any one of the systems, if properly installed, can be regarded as reliable, but the subdivision secured by the use of motors or small gas engines has advantages. The chief advantages of the electrical transmission system are its adaptability and the ease with which it can be extended, and its chief drawback is its cost, a part of which, at least, is due to the refinements which have been introduced into electrical controlling and operating mechanism.

Like the question of transmission, power generation depends for its solution upon the conditions of service. Where the power demand is intermittent, purchased electrical energy has advantages over all other systems, although for dock pumping, slipway haulage and other heavy intermittent loads, gas engines, using town gas, give economical service. For a moderately steady demand up to about 100 to 150 b.hp., the suction-gas engine has no rival. Above this load, it is possible to purchase a steam plant using highly superheated steam, which can generate 1 hp. per hour, at a fuel cost of a little over 1 lb., and a steam cost of approximately 8½ lb. Such a plant is, however, uncommon, and until it becomes more general, the range of usefulness of the suction-gas engine may be said to rise to 150 to 200 b.hp. Above this limit a steam plant using a low-grade fuel has advantages which have been greatly enhanced by the recent advance in the price of anthracite. The position of the steam engine or turbine for single-unit plants of over 200 b.hp. is not even today seriously assailed, except where the main question is complicated by side issues, or where the cost of coal is well above the average, the advent of the geared turbine being an interesting and pregnant development.

Where an electrical transmission system has been decided upon, the purchase of current demands first and careful consideration. If a private plant is to be installed then the generators may be either steam- or gas-engine driven. In the case of gas-engine driven generators the units may be of practically any size desired, while steam-engine driven units may be reciprocating engines up to 750 kw., and steam turbines thereafter. Interesting results can be got from the combination of reciprocating engines with steam turbines, a combination of this character giving a wide range of economical load at a modest capital cost. This advantage is obtained by cutting out the turbine from the lower loads and exhausting direct from the reciprocating sets to the condensers.

The sphere of usefulness of the large-power gas engine is confined mainly to situations where so called waste gas can be obtained, as at coke ovens and blast furnaces, or where a chemical plant is already installed.

In a works power plant the side issues also require consideration. The utilization of exhaust steam in turbines, of blast-furnace and coke-oven gas in large-power gas engines, and the development of the storage battery in connection with the fluctuating loads in large works, are all problems which warrant investigation.

Oiling the Largest Hydro-Electric Units

The power plant of the Mississippi River Power Co., now in course of construction at Keokuk, Iowa, will ultimately contain 30 generating units, with a rated capacity of 10,000 hp. each, at the normal head of 32 ft. At the maximum head of 39 ft. the output will be approximately 14,000 hp. each.

The waterwheels are the single-runner type and operate at 57.7 r.p.m. They are directly connected to vertical slow-speed generators. The turbines are the largest ever built and the plant is the first one of importance to contain slow-speed units.

All thrust bearings are a combination roller and oil-pressure bearing. As the total weight of the unit which each of these bearings supports is 275 tons, the importance of the oil supply is apparent. The oil is pumped to the bearings by Goulds triplex pressure pumps. It is supplied at a pressure of 250 lb. per sq.in., which is sufficient to lift each rotating member so that it floats on the oil and relieves the rollers of the load. These pumps have 6½-in. cylinders and 8-in. stroke and are operated by chain drive from line shafting.

The coal supply of Oklahoma is estimated to be ten billion tons. The state contains more than six million acres of coal-bearing land. Some of the land is estimated to be capable of yielding 7000 tons per acre.—"Coal Age."

The Prony Brake and Its Use

By H. M. Phillips

SYNOPSIS—An elementary explanation of the prony brake, common errors in its application and complete directions for using it correctly.

Most engineers consider themselves fairly familiar with the theory, if not with the practical use, of the prony brake; nevertheless, errors are common in its use. We know that a horsepower represents the performance of 33,000 ft.-lb. of work in one minute. If the work consists in lifting a weight, the simplest case, the weight times the number of feet through which it is lifted gives the foot-pounds. Now assume that the engine, motor, or other apparatus whose power is to be measured, is actually lifting a weight by means of a rope wound on a drum or pulley. The distance lifted per minute is obviously the circumference of the pulley (3.1416 times its diameter) times the number of revolutions per minute. Under ordinary conditions the weight would be lifted a considerable distance during the time required to take a satisfactory measurement; therefore, suppose that the pulley is allowed to slip so that the weight is suspended in air but remains stationary while the shaft revolves. The work done is the same as before, the weight is still being lifted, but merely falls back as fast as it is lifted. The manner in which the slip is accomplished, the size of the shaft, or other details have no bearing upon the amount of power required; the only essential is to obtain the speed at which the weight would be lifted if it were not allowed to slip back. In fact, all of the pulley except the hub and the point where the rope leaves its face could be cut away without altering the working conditions. We now approach the actual prony brake; it would, however, be very difficult to so adjust the brake friction as to keep a weight suspended in mid air without motion; hence the equivalent pull is measured by scales, or a spring balance, the latter for light loads.

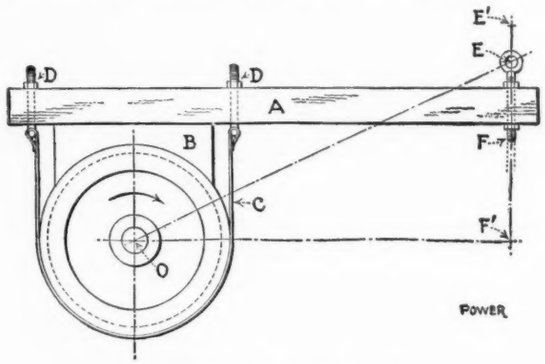
The construction of the brake varies considerably, being governed by the purpose for which it is intended, the material available, and the personal tastes of the designer, a common form is herewith illustrated, in which a wooden beam *A* has secured to it a block *B*, cut to fit the pulley; a band *C* is tightened on the pulley by the nuts *D*, the pull being measured by attaching a spring balance at *E* or allowing *F* to rest upon a scale platform.

For accurately determining the power absorbed by the brake, the number of revolutions per minute of the shaft, the length of the brake arm and the pressure exerted by the brake must be known. In determining the number of revolutions by the use of an ordinary revolution counter, some observers leave the counter in a little too long and obtain too high a reading, while others err in the opposite direction. If one is sure that the speed is constant he can detect this error by noting the revolutions for half a minute and then for a full minute or longer. If the counter is held in too long the half-minute reading will show the higher number of revolutions per minute, and *vice versa*. A number of readings should be taken to make sure that the difference is not purely accidental. Care should also be taken to hold the spindle of the counter in line with the shaft.

A tachometer is very convenient for determining the number of revolutions, but as it gets out of adjustment quite easily, some of its readings should be checked by a revolution counter.

Measuring the length of the arm is frequently a source of error, as it is often difficult to obtain an accurate measurement with the means at hand. Also, the proper points between which to make the measurement are mistaken by many; some imagine that the diameter of the friction pulley is to be considered in some way, but this has already been shown to have no bearing on the calculation.

Returning to the illustration and supposing the brake to be operated with its beam horizontal, the measurement is sometimes taken from the center of the shaft *O* to the points *E* or *F*, depending upon whether a spring balance or a scale is used. With all other conditions the same it is obvious that the balance would show the same reading whether the bolt were extended or the balance attached to a projection at *E* or lower; all these would give different measurements and consequently different results for the calculated horsepower. To determine the correct measurement, do not attempt to memorize or follow a fixed rule, but revert to the original theory. In the elementary case previously assumed, when hoisting the weight the pull of the rope must be tangential to the



Typical Prony Brake

pulley, or at right angles to the radius at the point of application. If we should hold the spring balance at right angles to the line *OE*, that measurement would fulfill the conditions and give a correct result, but it would be difficult to determine this position for the balance and practically impossible to arrange a scale to take the pressure in that direction. In setting up the brake the points *E* or *F* may be arranged to come on the same level as the center of the shaft, in which case the reading of the scale will be different from that obtained with the beam horizontal, and the measurement *OE* will be correct; the required conditions comparable to rope and pulley being fulfilled. Assume, however, it is desired to operate with the beam horizontal; then the distance *OF'* is the proper one to use in the calculations. With a plumb line locate the point on the beam that is directly over the center of the shaft and then measure along the beam to the line *EF*. It is also easier to set up the brake in this manner as one can judge with sufficient accuracy by the eye alone whether the beam is horizontal. On the other hand, it is not well to have too great a difference in level between the shaft and the points *E* or *F*.

In the calculations only the pull caused by the friction of the brake is considered, the scale reading due to the weight of the arm being deducted. This latter reading or "tare" may be determined in several ways; if the shaft revolves with considerable freedom, as with an electric motor, a reading may be taken while the pulley is at rest. An easy, although not absolutely accurate, method is to remove the brake arm and band from the pulley and support it by a bar while the reading is taken; in doing this, care must be taken to have the portion of the brake that is exactly over the center of the shaft rest upon the bar, in either case the weight must be taken with the beam in the same position, in which it is used during the test. Still another method is to loosen the brake band as much as possible and take a reading while running; then reverse the rotation and take another reading. Assuming the friction to be the same in each direction, half the difference of these two readings subtracted from the greater one gives the tare. In case the brake arm tends to rise when the rotation is reversed, sufficient weight may be added to keep it down during these two readings, the additional weight may be removed during the test. Tare may be eliminated by making the brake perfectly symmetrical about the shaft, but this tends to make it unnecessarily expensive and cumbersome.

Unless the action of the brake is perfectly smooth it is impossible to measure the pull satisfactorily; the spring balance is more apt to be affected by vibration than the scale, but has the advantage in some cases of allowing one to get at least a rough estimate of the pull where it would be impossible to obtain a scale reading. With a properly constructed brake, however, the scale will usually prove the more satisfactory. An oil dashpot attached to the brake arm will help, but to be effective it must be carefully adjusted, rigid and free from backlash. The tension on the brake band must be readily and quickly adjustable, for which purpose the use of a handwheel is preferable to a plain nut and monkey wrench. In any case care must be taken that the weight of the operator's hand or the pull he exerts in making adjustments is not registered on the scale. A satisfactory arrangement for light work is obtained by using a winged nut; by tapping this nut with a hammer very sensitive adjustment can be had.

To maintain a constant pressure on the beam the friction surfaces must not undergo any rapid changes during operation. To insure this they must be kept from overheating, lubrication must be maintained, and the pressure between surfaces must not be too great; failure in any of these will cause burning or cutting. In some cases the brake may be cooled by being flooded with water from a hose; this may be effective, but is apt to be hard on surrounding machinery and on the operator. Where possible a special pulley with inwardly projecting flanges should be used so that water may be carried inside the rim, centrifugal force holding it to the rim while the pulley is in motion. When a heavy load is carried an objectionable amount of steam may be liberated; in which event it is not difficult to provide water circulation and so keep the temperature below the boiling point. Pipe connections may be so arranged that one pipe will scoop water from the interior of the rim and carry it to a drain while another pipe introduces cold water.

Lubrication of the friction surfaces is necessary, and the material, shape and size of the rubbing surfaces are important in obtaining good lubrication. if the contact surfaces are too small they will be unable to carry away the requisite amount of heat, regardless of the cooling devices, and the temperature becomes too high for the oil; also, where excessive pressure is necessary the oil is unable to penetrate between the surfaces. The nature and shape of the material itself is important.

Very satisfactory results have been obtained with a band of ordinary sheet iron, as shown in the sketch, although such a brake would not carry as heavy a load as one with a different friction band. The load being light there is no great pressure between surfaces and the contact between the pulley and the band is irregular on account of the uneven surface of the latter. This is advantageous, inasmuch as it favors lubrication.

Two or more layers of heavy canvas between the band and the pulley will materially increase the capacity of this type. The canvas affords elasticity, gives a good bearing surface and acts as an excellent means of distributing the oil. It is generally possible to obtain satisfactory readings with this form of brake up to the point where the canvas is ignited by the heat of friction. Some of the more powerful brakes have wooden blocks secured to the band, similar to the brake frequently seen on a hoisting engine; but in this case the band usually nearly encircles the pulley, has its ends drawn together by bolts and has an arm secured to the band for weighing the load. The wooden blocks absorb oil and make an excellent friction surface, there is also ample opportunity to introduce oil or grease at almost any point.

A cheap temporary device for small pulleys may be made by using two blocks of wood cut to embrace a considerable portion of the circumference; a suitable arm is attached and the blocks tightened on the pulley by bolts. In this case it is well not to make too accurate a fit with the blocks; irregularities giving better opportunity for lubrication. Grooves may be cut in the blocks to further aid lubrication and cooling also if water is applied to the exterior of the pulley. In the latter case soap may be used as a lubricant; ordinary bar soap is cut in shavings and mixed with the water before it reaches the surface of the pulley; the water need be only moderately soapy to answer the purpose. For larger pulleys a sufficient number of strands of rope may be used in place of a band.

The capacity of a brake is always limited, for to absorb a definite amount of power it must be able to dissipate a definite amount of heat; but as the power is increased the point is approached where the cooling arrangements are unable to keep down the temperature. If the brake is to operate at a slow speed trouble may arise in attempting to get sufficient friction for the required pull without excessive pressure between the bearing surfaces, and unless the brake be properly designed its capacity will be limited by this fact rather than by heating; the capacity of such a brake will for a time increase directly in proportion to an increase in speed, but, however high the speed and perfect the lubrication, the point must finally be reached where the cooling device is inadequate. Several hundred horsepower may be absorbed by a brake constructed along the lines indicated.

While, theoretically, there is no reason why a brake should not be designed for any horsepower, if this runs too high the difficulty of providing proper lubrication increases, the apparatus becomes cumbersome and the cost prohibitive; in such cases special designs are used.

A detailed description of such brakes is beyond the scope of the present article, but a few words on the operating principle will suffice. In place of the pulley and band, revolving and stationary disks of thin sheet metal are used, these give considerable area of contact when pressed together and a number of pairs may be mounted on the same shaft without requiring excessive space. The disks may be provided with oil grooves and forced lubrication used if necessary. Also, the stationary disks may readily be arranged so as to have water circulation about the side not used as a friction surface, and as they are of thin metal the water will take up the heat very readily. We may go a step further and, using the disk as a diaphragm obtain any desired pressure on the friction surface by regulating the water pressure.

A much simpler arrangement which serves well for high, or moderately high, speed brakes is to make use of water friction for the braking effect. Such a brake may be made somewhat in the form of a single-stage Parson's steam turbine. On the rotating shaft a drum of any desired size is mounted which carries a number of rows of blades similar to the turbine blades, and an inclosing casing carries stationary blades of the same pattern, which enter with small clearance between the rows of revolving blades. Water introduced into this casing is subjected to a violent churning action. If the speed is sufficiently high the construction may be greatly simplified by doing away with separate blades and having water channels cast in the surface of the revolving drum, which enters with a small clearance into an inclosing cylinder provided with similar channels; clearance is provided all the way through so it is not necessary to have the cylinder in two parts. Water may be introduced conveniently by way of the interior of the rotating drum so that it will flow outward with centrifugal force. No lubrication is required, except for stuffing-boxes and bearings, and the same water provides both the friction and the cooling effects. If it is converted into steam no harm is done, although it is generally preferable to provide a sufficient flow of water to avoid this.

The principle of measuring the power is in no way changed, either with the water brake or the one previously described; in each case the pull is measured by a beam carried to scales and in each case the only factors to be considered in calculating are the amount of this pull, the distance, properly measured, from the center of the shaft to the point where the pull is weighed; and the speed at which the shaft rotates.

Condensing-Water Auxiliary Pump

By S. H. Farnsworth

A short time ago an article appeared in Power describing the Smoot-Rateau turbine installation at the southern works of the Illinois Steel Co.

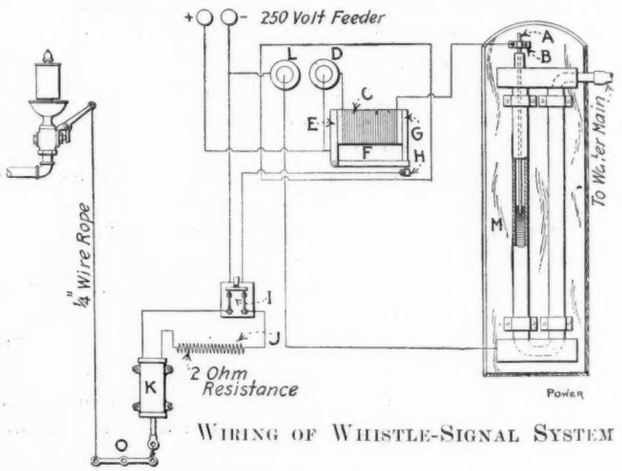
Engineers, knowing the important part fulfilled by the condensing apparatus in an installation of this kind, will be interested in the means of supplying water for it. The pumping station is about three-quarters of a mile from the turbine house and at the foot of the Worth Slip. It contains three DeLaval centrifugal pumps, driven by three 200-hp. Westinghouse, three-phase induction motors.

The building is of concrete and iron construction. The floor line is 10 ft. below ground and 5 ft. above the water level. A switchboard stands against the north wall. The knife switches are mounted above it. Each set is inclosed in a separate wooden case and operated from a platform parallel with and 10 ft. from the boxes.

In starting the motors, the 25-cycle, 2200-volt current is first sent through transformers and oil switches. When the motor comes up to speed the switch is released and 2200-volt current is cut in. This causes some shock and the wattmeter jumps to 300, but quickly settles down. About 40 amp. is the current required to carry the usual load. The motors are directly connected to the pumps, which are built for a 27-ft. head and each has a capacity, at 485 r.p.m., of 18,500 gal. per min.

Each discharge line has a swing-gate check valve and a hydraulically operated gate valve. A 1½-in. pipe leads from the top of the casing to an ejector, used for priming the pumps. The air is drawn out of the pump in about two minutes. The discharge lines from the three pumps join outside the station and then connect to a venturi meter.

When this station was first put into operation, trouble was experienced by the no-voltage release operating at most inconvenient times, stopping the pumps. The supply of cooling water being thus cut off, the condensers would be put out of service, further reducing the voltage. Therefore, these devices have been removed and now, if



Wiring of Whistle-Signal System

the voltage should drop below 800 volts, the switchboard operator notifies the engineer at the central pumping station to not build up the voltage until sure the pumps are running.

As this pumping station has no regular attendant a signal had to be devised to notify the engineer, when the head fell below a predetermined point. The device shown in the illustration was installed and gives good satisfaction. A 5-ft. U-tube is mounted on a board fastened to the wall. The right leg is connected by a hose to a ¼-in. water pipe leading to the water main beyond the venturi meter. The left leg has a rubber cork inserted, through which a length of No. 10 copper wire *A* passes down into the mercury with which the U-tube is half filled. The wire *A* is held in a bracket *B*, by a setscrew, so that by raising or lowering *A* its point of immersion is changed and the signal can be made to operate at any desired water pressure.

The bracket *B* is electrically connected to an electromagnet coil *C*, taken from a 50-hp. shunt-wound motor.

The other terminal of the coil is connected to a 125-volt lamp *D*. The other wire from *D* connects with the positive side of a 250-volt feeder. *E* is a piece of ¼x¾-in. steel fastened to the coil, but insulated from it. It is slotted to receive a ¼x¼-in. piece of steel, hinged at one end in *E*. *G* is a piece of ¼x¼-in. steel fastened to the coil. *H* is a nickel-steel contact piece in circuit with the switch *I* and resistance coil *J* and the solenoid *K*. The other side of *K* is connected directly to the negative side of the 250-volt feeder. A wire connects this feeder and the lamp *L;* the other side of *L* is grounded on the mercury column.

When the pumps are in operation and the pressure is normal, the mercury is raised in the leg *M* of the U-tube and makes contact with *A*. Current then flows from the positive feeder through the lamp *D*, coil *C* and bracket *B* to the mercury. Then into the grounded wire, then on up through the lamp *L* into the negative feeder. The coil *C* is thus energized and the lamps *L* and *D* are lighted. The armature *F* is raised by the magnetism in *G*.

When the water pressure decreases, the mercury recedes in the leg *M* of the U-tube until the wire *A* is out of contact with it. As the circuit is broken the coil *C* is de-energized and the armature *F* drops, making contact with *H*. Current then flows from the position feeder through *E, F, H, I, J* and *K* to the negative side of the line. This energizes the coil in *K* which raises the plunger and blows the whistle, the lever of which is connected to the arm *O*. A telephone line runs from the turbine station to the pumping station; but, owing to inductance, it is little use.

Another electric-driven pumping station is at the foot of the Southern Slip, about five miles south of the central pumping station. It contains two 30-in. centrifugal pumps driven by three-phase, 25-cycle, 2200-volt induction motors. These sets are used to supply water for barometric condensers, which require 30,000,000 gal. per 24 hr. When this station was first put into operation much trouble was caused by lack of a satisfactory priming device for the pumps. The nearest steam main is about two blocks away and the line had to run in such a tortuous and exposed way that the drop was excessive and unless the boiler pressure was better than 140 lb. the siphon would not work.

As a high-pressure fire main ran underground past the station it was decided to try water to work the siphon.

A system was perfected to prime the pumps with about 2.5-in. vacuum in the siphon suction leading from the pump. To get the siphon to work it was necessary to reduce the discharge nozzle until the water completely filled in, for, if eddies formed in the nozzle, air would find its way back to the suction line.

It was found that much better results were obtained by connecting the siphon suction into the suction casing directly over the center of the impeller shaft, instead of the top of the discharge casing. It seems that the impeller throws what water there is in the pump out against the discharge casing, leaving the air imprisoned in the center of the impeller. The discharge pipes contain check valves and electrically operated gate valves. They are fitted with safety circuit-breakers so that they cannot be opened or closed far enough to jamb.

The no-voltage release is so arranged that, when operated, it forms a circuit in a 250-volt line sounding a gong in the pump house and in the engine houses, giving notice to run noncondensing until the voltage is built up.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We hope you didn't dodge the foreword in this issue, "The Business End of the Power Plant." Dodging the business end of a mule is different; this foreword is a kick for you, not at you. Read it twice, digest this "food for thought," and pass it on to the man higher up. There'll be more along these lines in early issues, each with a punch in it. Watch out for 'em!

❖

And speaking of digestion, did you know that Horace Fletcher has just finished his Christmas dinner, thus beating last year's record by 4 days 6 hr. 7⅛ min.?

❖

It is reported in political engineering circles that engineer Bryan, over to the Washington plant, is using grape juice as a throttle lubricant. When we indorsed the Wilson brand, we little thought that this Cabinet engineer would try to run on this grape stuff.

❖

Great guns! Somebody claims that the modern cannon suggested the application of explosive gases in the driving of engines. Warlike implements have their victories no less renowned than peace.

❖

HELP WANTED!

By Billy Spills

A lady reader from Pennsylvania has suggested this picture as a fair sample of the difficulties encountered by the operating engineers in the Home plant. "If the engineer thinks his job is hard," writes friend lady, "how about the engineeress he leaves at home?"

Husbands and fathers, this looks like hard lines! Here's a seven-day, overworked isolated plant which must keep the consumers supplied while operating under great difficulties. Fix your eye on that little unit in the high chair; looks like a case of leaky condenser. The big lad has cut in with a troublesome bleeder. The superheater in the background has a leaky nipple. The supply man has butted in and invites the engineeress to make him shut down, shut up, and make 250 r.p.m. for the front gate.

And all these troubles seem to occur just at the peak of the load. Now that your eyes are opened, what are you going

A Busy Day at the Home Plant

to do to lighten the white woman's burden? What can be done?

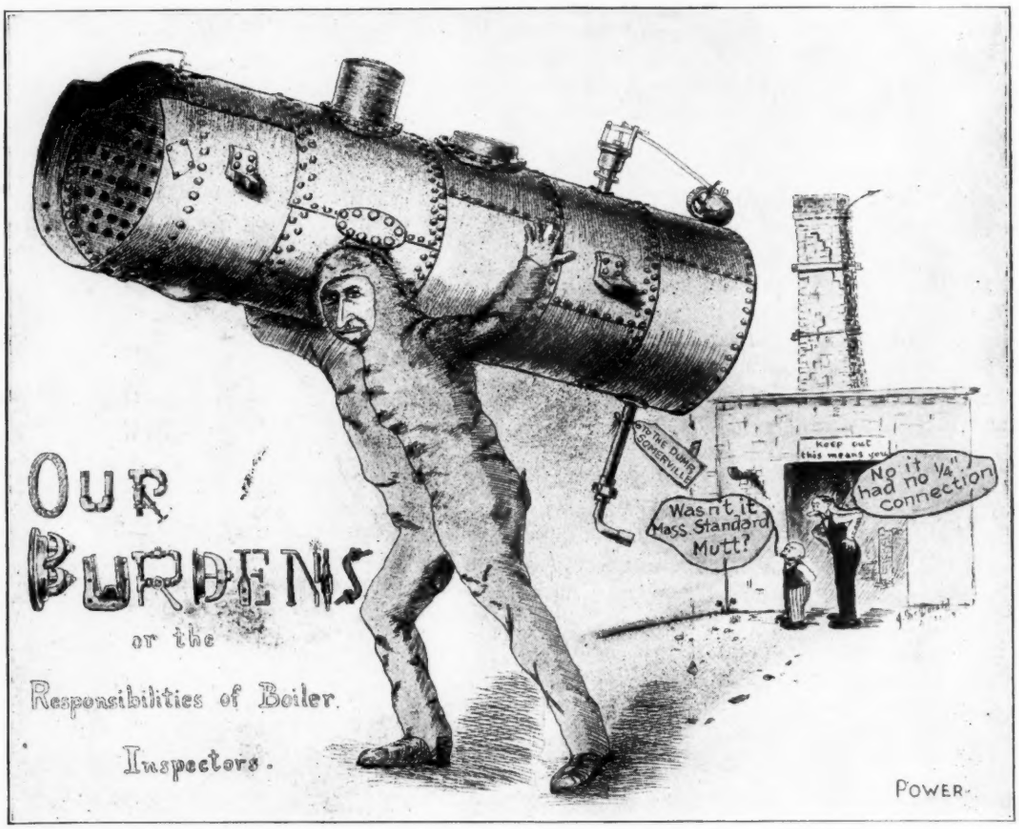
We are dinged regretful that this column can only give publicity to this parlous state of affairs. At this writing there's a big suffragette parade going on in Noo York, and we will seek out the engineeresses, firewomen and coal-passettes division and see if "Votes for Women" has a remedy. But we balk at changing places with any Home plant engineeress; this is no remedy.

LATER—Found no operating remedy in the parade. Console yourself, dear lady, by the thought that "the hand that rocks the cradle rules the world"—and make the old man hustle for more "rocks!"

Boiler Inspectors' Dinner

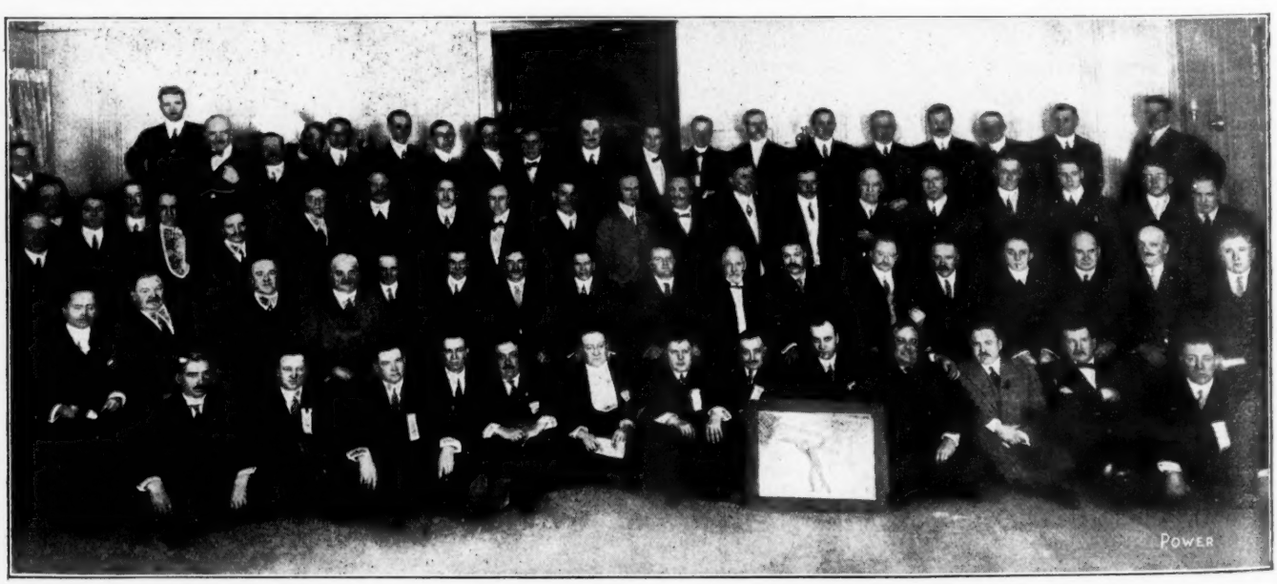
Very substantial evidence of the growth of the American Institute of Steam Boiler Inspectors was had in the number attending its fourth annual dinner, Apr. 30. It was held in the Quincy House, Boston, Mass., and followed the business meeting and election of officers. The latter for the year 1913-1914, are W. G. Young, president; Herman Van Ormer, vice-president; John H. Gleason, secretary; Adam Oldfield, treasurer; F. G. Wright, E. J. Scanlon, E. R. Doherty, W. T. Eastman, H. H. Coyle, executive committee. Messrs. Young, Van Ormer, Gleason and Wright are with the Hartford Steam Boiler Inspection & Insurance Co., Mr. Oldfield, the Casualty Company of America; E. J. Scanlon, the Maryland Casualty Co., Messrs. Doherty and Eastman, the Mutual Boiler Insurance Co., and H. H. Coyle is with the Traveler's Insurance Co.

Prominent at the meeting and again at the dinner was the cartoon drawn for the occasion by James McDonald, and reproduced herewith, "Our Burdens." It was remarked by several that any boiler with single-riveted lap seams and double-riveted girth seams ought to be thrown out.



JAMES MCDONALD'S CARTOON, WHICH MADE ITS DEBUT AT THE BOILER INSPECTOR'S DINNER.
(Acknowledgment is made to Bud Fisher for the use of Mutt and Jeff)

The list of speakers was so long that contrary to usual custom the first were called upon before coffee was reached, so, as at the three-ring circus, there was an embarassment



ATTENDANTS AT THE DINNER OF THE AMERICAN INSTITUTE OF STEAM BOILER INSPECTORS

of riches—in good things to eat and good things to hear at the same time.

Andrew J. Savage, the veteran boiler inspector, oldest in the east, if not in the country, was the first heard from and received a warm ovation. It will be impossible to more than name the rest of the speakers who were as follows:

P. H. Hogan, past president of the National Association of Stationary Engineers; J. C. Shaw, president of the New York branch of the American Institute of Steam Boiler Inspectors; John A. Collins, secretary Mutual Boiler Insurance Co.; James Stewart, Stewart Boiler Works; G. Hill Smith, engineer; George B. Clark, Edgemoor Boiler Works; T. T. Parker, chief inspector, Fidelity & Casualty Co.; D. M. Dillon, Dillon Boiler Works; William Ranton; H. R. Cobleigh, "Power"; H. V. Brady, International Engineering Co.; Henry Lynch, representative of the Board of Boiler Rules of Massachusetts and with the Hodge Boiler Works; John A. Stevens; W. O. Young, the newly elected president; Charles Coopman, New England Iron Works; Professor J. C. Riley, Massachusetts Institute of Technology; J. G. Gillespie, Royal Insurance Co.; Robert Thompson, Traveler's Indemnity Co.; James White and Augustus Lloyd.

For an altogether highly successful and enjoyoble evening much credit is due to Frank G. Wright, who acted as toastmaster, and to Herman Van Ormer, chairman of the entertainment committee, and T. G. Ranton, chairman of the educational committee.

Explosion of Boiler Kills Owners

A steam boiler used to operate a pumping plant to raise water for irrigation purposes near Selma, Calif., exploded on the afternoon of Apr. 20, instantly killing Frank Rouch, the owner, and seriously injuring his son. The boiler was an old one and had formerly been used in a traction engine. There was no property loss exclusive of the boiler.

Coming N. A. S. E. Conventions

A list of the Central States National Association of Stationary Engineers was published in "Power," of May 6. Below are additional conventions with cities and dates:

STATE CONVENTIONS

Newark, N. J., May 22 to 25.
Yonkers, N. Y., June 12 to 14.
Meriden, Conn., June 26 to 28.
Chester, Penn., June 27 to 28.
Lawrence, Mass., July 10 to 12.
Clarksburg, W. Va., ——— ———

NATIONAL CONVENTIONS

American Order of Steam Engineers, Philadelphia, Penn., June 2 to 7.

Canadian Association of Stationary Engineers, Owens Sound, Ont., July 29 to 31.

Universal Craftsmen, Council of Engineers, Boston, Mass., Aug. 4 to 9.

Eccentric Firemen's Association, Pittsburgh, Penn., Aug. 11 to 16.

National Association of Stationary Engineers, Springfield, Mass., Sept. 8 to 13.

Marine Engineers' Beneficial Association, Washington, D. C., Jan. 19 to 24, 1914.

International Union of Steam Engineers, Peoria, Ill., September, 1914.

A. S. M. E. Baltimore Program

The spring meeting of the American Society of Mechanical Engineers will be held at Baltimore, Md., May 20-23, at the invitation of the Engineers' Club of Baltimore and the local members. The professional sessions have been arranged as usual, while all other events are in charge of the local committee under the chairmanship of Layton F. Smith, past president of the Engineers' Club of Baltimore.

THE PROGRAM

Tuesday, May 20—Registration of members and guests at headquarters, Hotel Belvedere.

Tuesday Evening—Membership reunion and informal reception.

Wednesday, May 1—Business Meeting, 9:30 a.m.: Report of tellers of election of members. Announcement of ballot on amendments to the constitution relating to membership grades. New business.

Reports of special committees on Myriawatt, Involute Gears, Standardization of Catalogs, Code of Ethics and National Museum. Simultaneous sessions following business meeting.

Professional Session—Papers: "Test of a Hydraulic Buffer," Carl Schwartz; "The Present Condition of the Patent Law," Edwin J. Prindle; "Shading in Mechanical Drawing," Theodore W. Johnson; "Cost of Upkeep of Horse-Drawn Vehicles against Electric Vehicles," W. R. Metz.

Gas-Power Session—Business meeting. Paper, "Present Operation of Gas Engines Using Blast-Furnace Gas as Fuel," Charles C. Sampson.

Wednesday Afternoon—Demonstration of the high-pressure fire system at City Hall plaza, and inspection of pumping station, followed by a sail about the harbor to inspect the water front, shipping facilities, and other features of interest.

Wednesday Evening—Lecture, illustrated by lantern views: "Around the World in Eighty Minutes," Hon. O. P. Austin, secretary, National Geographic Society.

Thursday, May 22—Fire Protection Session, 9:30 a.m.: "The Baltimore High-Pressure Fire Service," James B. Scott; "National Standard Hose Couplings and Hydrant Fittings for Public Fire Service," F. M. Griswold; "Department of City Conflagrations," Albert Blauvelt; "Allowable Height and Area in Factory Buildings," Ira H. Woolson; "The Protection of Main Belt Drives with Fire Retardent Partitions," C. H. Smith; "The Life Hazard in Crowded Buildings Due to Inadequate Exits," H. F. J. Porter.

Thursday Afternoon—Inspection of sewage pumping plant, Jones Falls conduits, and trip by trolley to sewage-disposal plant at Back River. Automobile trips for ladies, about the city and suburbs, with tea served at the Country Club.

Thursday Evening—Reception and dance. The society will be the guests of the Engineers' Club of Baltimore on this occasion.

Friday, May 23—All-day excursion at Annapolis, and the U. S. Naval Academy with a reception by Governor Goldsborough at the State House. After the reception the party will proceed to the Assembly Chamber where Admiral H. I. Cone, engineer-in-chief of the Bureau of Steam Engineering, U. S. N., will deliver an address upon the United States Experimental Station at Annapolis. Luncheon will be served at the Carvel House. In the afternoon, there will be a band concert by the Naval Academy Band, and a dress parade at 6 o'clock, which may be witnessed by those finding it convenient to remain. It is expected that there will be hydro-aëroplane flights by officers and men of the aviation school, and evolutions of the submarine boats stationed at Annapolis.

N. A. S. E. Business Legalized

A bill to legalize the conventions and business transactions of the National Association of Stationary Engineers, when such transactions were made outside the state of New York, recently passed the New York Legislature.

Although no conventions or business transactions outside this state were questioned, the officers felt that it was best to legalize all past and pending business in states other than New York.

Dinner to Prof. Hollis

On Tuesday evening, Apr. 29, a dinner was given in honor of Prof. Ira N. Hollis, formerly of Harvard University and recently appointed to the presidency of Worcester Polytechnic Institute. The members of the Boston sections of the American Society of Mechanical Engineers, the Civil Engineers and the American Institute of Electrical Engineers gave the dinner, which was held at the Boston City Club. Among other distinguished educators present were Dr. Richard C. MacLaurin, president of Massachusetts Institute of Technology, and Dr. A. Lawrence Lowell, president of Harvard university.

At the conclusion of the dinner two papers, illustrated by lantern slides, were presented, "Some Phases of the Development of the Grand Central Terminal," by George W. Kittredge, chief engineer of the New York Central Lines, and "Problems in Local Transportation," by Matthew C. Brush, second vice-president of the Boston Elevated Ry. Co.

W. A. Bone, of the University of Leeds, and C. D. McCourt, of London, have taken out an English patent upon a grate or hearth for the application of the Bone system of surface combustion to an ordinary furnace.

Exaggerated Flood Reports

The Platt Iron Works Co., Dayton, Ohio., is another company whose condition has been exaggerated by recent flood reports. B. K. Gantt writes as follows:

"While it is true that we have suffered considerable damage, our buildings were practically uninjured and we have recovered more quickly than we anticipated. The second day after the water subsided we had steam up and the work of removing the mud and débris was started. Our entire organization responded most loyally toward getting the plant in operation, irrespective of the fact that many of them suffered personal loss due to the flood. A small portion of our plant was put in operation Apr. 7 but as a large number of our machine tools are equipped with individual motor drives we were obliged to bake and clean these motors and did not start up in all departments until Apr. 21. We are now prepared to accept and fill all orders promptly."

Bureau of Licenses Not to Inspect Boilers

During the last session of the New York Legislature, Senate bill No. 2499, which, in effect, was to permit New York City to transfer the duties of boiler inspection and the licensing of engineers and firemen from the Police Department to the Bureau of Licenses was not "brought out of committee." It is considered that the bill will now be lost by default.

Hydro-Electric Enterprise in Italy

It is reported that arrangements have been completed for carrying out several important hydro-electrical projects in Italy. The Societa per le Forze Idrauliche della Sila is about to erect a large power station in southern Italy to generate 50,000 hp. The generating station will be at Cosenza, in Calabria, and part of the power will be consumed on the spot for the manufacture of calcium carbide, the remainder being transmitted by cables to various centers. The preliminary capital will be about $8,000,000. If necessary the water power available can be made to generate 150,000 hp. A power station is also being erected in Sardinia to electrify the power of the River Tirso. About 15,000 hp. will be generated, and will be taken by the numerous mines in the district.

A new generating plant is being laid down in northern Italy by the Societa Ligure Toscana di Elettricita. The new station will generate 15,000 hp.

The State railway authorities have just entered into a contract for the supply of power in connection with the electrification of the Ronco-Sampierdarena-Genoa line. The power station will be completed in a few months and will generate about 50,000 hp.

In central Italy, too, several hydro-electrical power stations are to be erected. The water power in central Italy is said to be considerable, representing close on 400,000 hp.

SOCIETY NOTES

The institution of Engineers and Shipbuilders in Scotland and the Institution of Naval Architects have arranged a joint summer meeting, which is to be held in the rooms of the Scottish Institution, Elmbank Crescent, Glasgow, on June 24, 25, 26 and 27.

The eighteenth annual convention of the National Association of Manufacturers will hold its annual convention on May 19, 20, 21, at Detroit, Mich. This organization, composed of 4000 of the largest firms in the country, has in recent years held its annual sessions at New York, the importance of its discussions and the prominence of its speakers attracting an attendance of approximately a thousand representatives of large employers throughout the United States.

The proceedings of the association this year will be of exceedingly great interest to manufacturers and employers everywhere on account of the change in the national administration, the application of new tariff schedules, the legislative enactments designed for the regulation of business, both big and little, the general economic unrest, and the ever-sharpening aspects of the labor situation. The convention, which will be at the Hotel Pontchartrain, will witness the inauguration of many new policies and plans for the betterment of industry, notable features being addresses and reports on accident prevention and workmen's compensation, industrial education, fire prevention, export trade, patent reform, currency and banking, immigration, interstate commerce and federal incorporation, consular reform, bankruptcy, uniform state laws.

The opening address will be by Mayor Oscar B. Marx, of Detroit, followed by an address of welcome by James Couzens, president of the Detroit Chamber of Commerce.

In connection with the report of the Committee on Accident Prevention and Workmen's Compensation there will be a notable exhibit of safety devices; Ferd. C. Schwedtman, chairman of the committee, will deliver an address, incidental to which lantern slides and moving pictures will be shown, followed by a discussion by J. A. Robertson, of the Eastman Kodak Co., Rochester, N. Y.; J. P. Douglas, of the United Gas Improvement Co., Philadelphia, Penn., and L. B. Robertson, of the Ford Motor Co., Detroit, Mich., and others. The session devoted to industrial education will consist of a report by the committee and addresses by H. E. Miles, chairman, and Dr. John H. Leete, Dean of the School of Applied Science of the Carnegie Institute of Technology, Pittsburgh, Penn.

PERSONALS

J. K. Haigh, for 10 years connected with the Snow Steam Pump Works in Buffalo, has been transferred to the company's Los Angeles office.

The Hon. William C. Redfield has resigned as vice-president and a director of the American Blower Co., Detroit, Mich., since his appointment as Secretary of Commerce in President Wilson's cabinet.

John Hays Smith, commercial engineer of the Milwaukee Electric Ry. & Light Co., in charge of engineering and sales of electric power and steam heat, has resigned to engage in consulting engineering, with offices in the Merrill Building, Milwaukee. Before coming to Milwaukee Mr. Smith was with the Duquesne Light Co., Pittsburgh, and was with the Westinghouse Electric & Manufacturing Co. for seven years.

A Diesel Engine, built by the Busch-Sulzer Bros. Diesel Co., St. Louis, Mo., for the Hugo, Oklahoma, Ice & Light Co., was tested recently by A. T. Scott, Dallas, Tex. The engine is a three-cylinder machine, rated at 225 net b.hp., direct connected to a generator. The fuel consumption in various rates of output was as follows:

Net brake hp.	Oil burned per net brake hp.-hour, lb.
49.7	0.769
111.39	0.482
162.97	0.454
219.63	0.441
245.6	0.444

The air compressor furnishing the air for starting the engines and injecting the fuel supply was driven by power from an independent source. The current used to drive this compressor was deducted from the output of the generator to obtain the net brake-horsepower. The engine tested had been in operation for six months. The oil used showed on analysis 18,986 B.t.u. per lb. of oil; the specific gravity was 0.8531, and it had a viscosity of 92 degrees F. of 1.63. Analysis of the exhaust gases showed that no combustibles remained in them.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Buzzards Bay Electric Co. has been granted a franchise to construct and operate an electric-light plant at Chatham, Mass. H. H. Taylor, Falmouth, Mass., is superintendent.

Plans are being prepared by the Berkshire St. Ry. Co. for the construction of a new substation at Lee, Mass. C. L. Richmond, Pittsfield, Mass., is general manager.

A committee has been appointed to investigate the feasibility of installing a water system at Somerset, Mass. D. B. Davis is town clerk.

The city council of Chambersburg, Penn., is considering the proposition to appropriate $30,000 for the improvement of the municipal electric-light plant and the installation of new equipment.

The village authorities of Lawrenceville, Penn., are considering plans for the installation of a water system.